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The Bridge of Dreams

Towards a Method for Operational Performance Alignment in IT-enabled Service Supply Chains

PROEFSCHRIFT

ter verkrijging van de graad van doctor
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prof. dr. E.H.L. Aarts,
in het openbaar te verdedigen ten overstaan van een
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“If you think you understand something, you have not thought about it enough.”

--- Richard Feynmann

ACKNOWLEDGMENT

I believe every PhD candidate has his / her own motivation for making such a long-term commitment. Mine was a piece of hand-drawn diagram, collaboratively done by my supervisors prof. Henk Akkermans and prof. Willem-Jan van den Heuvel during my PhD interview. They drew the 'bridge of dreams', which aims to connect research in information system and operations management on IT-enabled service supply chains. I immediately liked this ambitiously interesting idea. That was the start of my PhD story.

A PhD study is a learning process for becoming an independent researcher. Many people think someone must be really smart because he / she is doing / has done a PhD. This probably is true. This thesis presents some knowledge and capabilities that I obtained from conducting the PhD research. But what could not be expressed in words and definitely makes me a better person is, if there is any, the wisdom grown from being capable of 'doing something or talking to someone not in your field'. This is simply what has been reported in this thesis, and hopefully I am able to show a little wisdom in it.

The journey of seeking the 'bridge' was tough but has been worthwhile. It was a great once in a lifetime experience and I had the luxury of muddling through interdisciplinary research fields and practice. I am thankful for this unique experience and appreciate all the support and help received along the way.

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To all my dear friends and colleagues during my Tilburg time, thank you for sharing so many nice moments and making the good memories. I will always remember that! Thank Geert and Gaia for keeping pushing me to finish this thesis (and finally it is here J). Gaia, Juan and Sara, I am very glad and proud that we keep the promise to be each other's paranymphs. Your support goes no doubt beyond the doctoral defense. Thank you!

I feel very lucky to have a family that is very open and supportive. Hopefully this thesis could show them some little things I have done during past years.

My PhD journey is going to end here, but work goes on.

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CHAPTER 1

INTRODUCTION

The transformation of service provision from traditional human based provision toward technology based format is being witnessed every day. Information technology (IT), in particular the internet, mobile technology and information system (IS), have made service platforms highly or completely IT-enabled. The increasing extent of service digitalization makes the world global, ubiquitous, always on, always connected and smart [7].

Many initiatives, such as Germany's industry 4.0 and China's internet plus etc., have been promoted substantively to encourage the integration of digital computing and information and communication technology (ICT) applications within traditional industries. The Internet of Things (IoT) [8] paradigm is maximizing the wave of digital transformation not only by integrating ICT solutions but also by synergizing knowledge from different fields, such as telecommunications, informatics, social science and so on.

What comes along with the booming trends in digital transformation is concerns over service reliability and infrastructure stability. It is not uncommon to see failure in IT-enabled services. What even worse is that the impact of IT-enabled service failure is immediately perceived by customers. For instance, Whatsapp suffered global failure on New Year's Eve 2015 due to the huge volume of data transmission. Users of Dutch telecom and ICT provider KPN suffered from service failures in internet, interactive TV and telephony in November 2015, while in the same month, Orly airport in Paris was forced to shut down due to the computer system crashing in bad weather.

While these incidents in service operations have obvious impact and are often noticeable by whole communities, the following incidents in IT development also attracted author's attention. In October 2014, Dutch parliamentary research [9] on seven major government ICT projects conducted over a two year period reported that the Dutch government could not properly manage information processes and flows using ICT applications, and was wasting between 1 and 5 million euros annually on ICT failures. The Dutch government is not alone in having a failed ICT project in digital transformation. According to a study by Genpact [10], large enterprises spend 400 million dollars a year on failed digital projects, accounting for two thirds of total digital transformation projects.

All the above mentioned incidents, although seemly unrelated to each other, draw attention on the alignment between the development and operation of IT-enabled services, as well as the alignment between IT performance and business service performance. IT-enabled services create a new business market, while the development and operation of this type of service has direct impact on business success and requires tremendous coordination efforts in the supply chain. From the perspective of research on information management, it is time to resurrect a classic topic and introduce it into the current service research context, viz. business-IT alignment in the IT-enabled service supply chain (SSC).

1.1 Coordination challenges on marrying IT with SSCs

Coordination is commonly used to achieve alignment in general supply chain management (SCM) [11]. This research is motivated by the challenges found in coordinating IT-enabled SSCs. Effective coordination is of great importance in keeping all supply chain (SC) entities functioning smoothly and fulfilling SC demands. The increasing involvement and enabling role of IT changes the type of SC activity and demands a new mindset and different tactics for managing IT-enabled SSCs.

1.1.1 Coordination and IT in supply chain management

In SCM, coordination is often used to achieve alignment [11]. Alignment in SCM has various aspects, namely the supply chain and (cross) organizational processes, the trust and information sharing in the supply chain, and the decision making and partnerships [12].

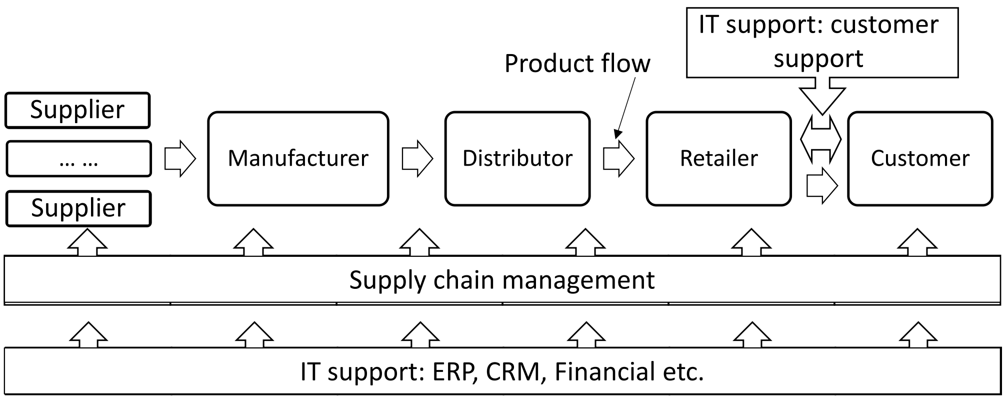
Coordination activities in supply chains are carried out differently due to the variety of types and IT settings in different supply chains. The type of supply chains is evolving from a product-oriented manufacturing supply chain to a service-oriented supply chain. The role and involvement of IT in supply chain management (SCM) has been expanding its reach and range. From coordination perspective, it is interesting to compare coordination mechanisms in different types of supply chains with an emphasis on the role of IT.

Coordination and IT in traditional supply chains

In traditional supply chains, organizations, people, activities, information and resources are all involved in the manufacture and supply of goods to customers. From an operational perspective, coordination (Figure 1.1) makes sure that the flow of goods and services through a supply network stays within certain control limits, so that undesired supply chain behavior does not occur [13]. In this sense, coordination activities do not change the supply chain work flow, nor rely on massive data collection and manipulation in the supply chain.

Adopting IT systems has greatly enhanced SCM by improving supply chain efficiency and effectiveness [14] [15]. IT applications, such as ERP systems, are of beneficial support to SCM and coordination. IT also increases communication across the supply chain, and facilitates collaborations among SC partners [16] [17]. According to all of these research perspectives, IT holds a purely supportive role, which is, naturally, important and critical, but not a life-threatening element in business success. Most operations in which IT applications are used already exist in supply chains. Without IT applications, it is possible to find alternatives to manage and coordinate these operations, and to keep supply chains running.

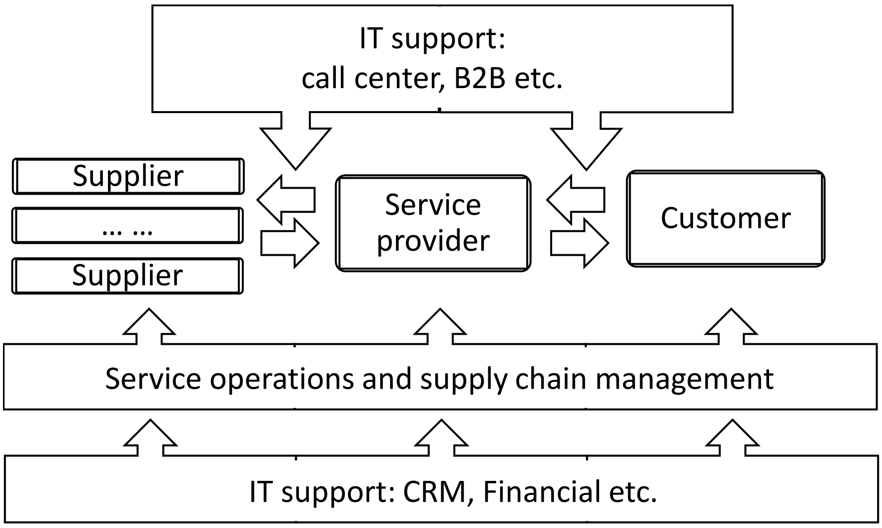
Figure 1.1: Coordination and IT in traditional supply chains



Coordination and IT in service supply chains

Coordination in SSC (Figure 1.2) is more complicated than in traditional goods supply chains. A service product can be a pure service or a physical product with significant service considerations [2], which is more complex than a goods product. The difference between SSC and goods supply chain comes from the unique characteristics (e.g. intangibility, perishability, inseparability, and variability) of a service product, as well as the heavy involvement of customers in value co-creation. Compared with goods supply chains, it is harder to measure the performance of services and the SSC. This is due to the many soft or subjective measures, such as customer satisfaction, service quality etc., that are used in SSCs [18].

Figure 1.2: Coordination and IT in service supply chains



For SSCs, the essence of coordination is to align the behaviors of all involved service participants in order to achieve the best (possible) performance in a supply chain system. As reviewed by Wang et al. [2], most coordination challenges in SSCs, e.g. customer services, outsourcing, performance-based contracts, logistics services or financial services and so on, are concerned with SSC participants' involvement and how the service delivery is ensured through multiple levels of participant interactions. People oriented coordination mechanisms are required in SSC. For instance, it is more effective to coordinate SSC if the supply chain player who is closer to the market is allowed to lead the coordination [19].

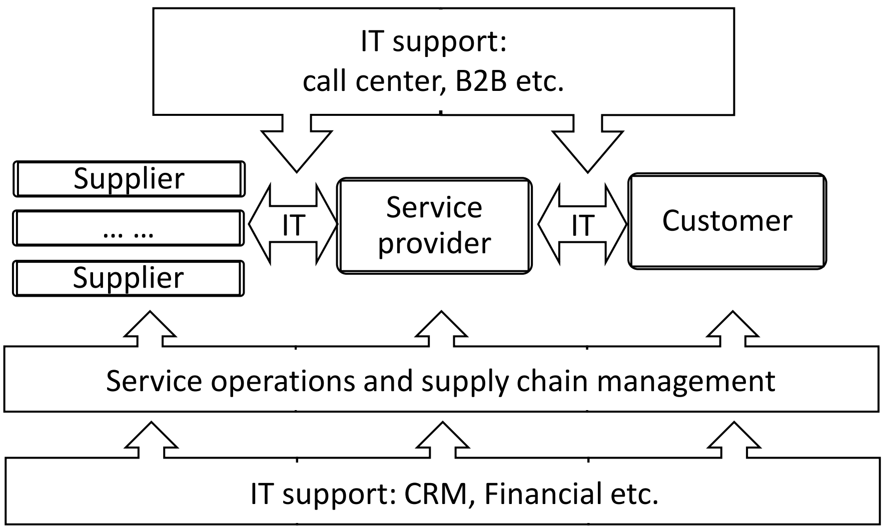
With respect to the role of IT in SSC, it contributes greatly to supply chain information sharing, in addition to its general support role in SCM. Coordination effort is essential for maintaining the communication and information linkages with customers and among supply chain players [20]. Customers are part of the service creation process in SSC and ICT applications are used to create communication interfaces so that real-time customer information and requirements can be generated and shared to achieve better supply chain management.

Coordination and IT in IT-enabled service supply chains

IT-enabled SSC is a special type of SSC, where the services received by customers do not function without IT applications. The products of IT-enabled SSC are usually pure services while physical products only function as basic service infrastructure. These services are often found in industries such as telecommunication, internet services or mobile apps[2]. They are also found in banking, insurance, tax, and more and more in infrastructure utilities, such as electricity, water and so on. Although these services already existed long before the development of IT systems, they nowadays are increasingly digitalized and have become IT-enabled.

While the main coordination goal is aligned with general SSCs, the core activities are carried out in an environment which has less human interaction. The business processes in IT-enabled SSC are highly automated [21]. Therefore operating IT applications becomes an important part of coordination activities. IT applications are the major enabler and the interface for carrying out service operations in IT-enabled SSC. Instead of being primarily in a support role for business service operations, IT applications and systems have become the primary business process itself (Figure 1.3), the core service and also an enabler for business transformation [22].

Figure 1.3: Coordination and IT in IT-enabled service supply chains



1.1.2 Operational performance alignment in IT-enabled SSC

From reviewing the evolving role of IT in SSCs above, it is clear that the relationship between business and IT is changing, and IT applications are taking more important roles in business. Nevertheless, the main alignment focus is still on service operation. There is less attention paid to service development, which is understandable since services are co-created by service providers and customers. However it works differently in IT-enabled SSC, given the enabling role of IT applications in the services.

In IT-enabled SSC, IT-enabled service innovation and development is closely associated with IT development. It is imperative that IT development is included in the scope of IT-enabled SSC coordination, since all service operations are carried out via the developed IT applications. Unfortunately, there is a gap in current research when it comes to this issue. The software SSC [23] and IT-enabled SSC[21] are still studied separately by researchers.

Studies in software SSCs, are concerned with alignment between software service development teams and operation teams. Coordination tactics, such as DevOps approaches, are undertaken to improve alignment between IT development and IT service operation for better service delivery [24]. There is a strong correlation between the quality of DevOps interactions and service revenue growth [25]. Unfortunately studies in IT-enabled SSCs have not helped generate sufficient attention to coordinating IT development with the rest of the service operations. Studies that take a holistic scope to research business-IT alignment in IT-enabled SSCs are lacking.

1.2 Research Problem

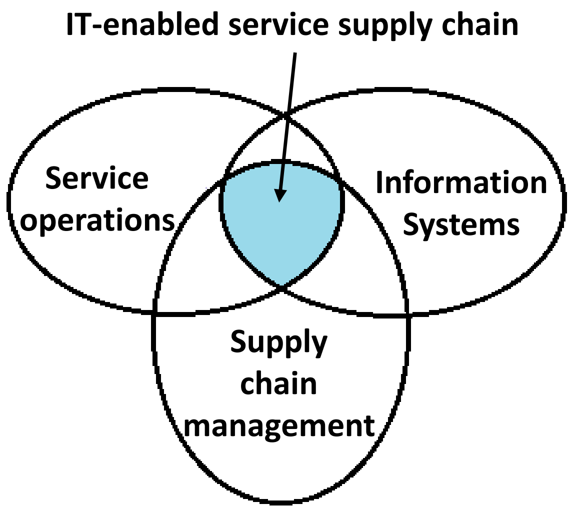
Concerns on performance alignment, especially on business-IT alignment, have been around for three decades. It is still considered to be one of the most important driving forces for business success, as well as one of the top concerns of many practitioners and organizational researchers [26]. It is also found to be a major issue in two thirds of digital transformation projects [10]. Many attempts from researchers in diverse disciplines have been made to tackle this issue. Unfortunately, they have been working separately and the research appears in various forms and names, such as enterprise architecture and engineering in IS, or strategic alignment in management science.

Much of the research into SSC remain as explanatory science. Despite research on identifying performance alignment issues, the challenge of transforming that research into a solution still remains. On the one hand, the challenge comes from a theoretical perspective. Despite the numerous methods, tools and approaches that have been proposed to achieve alignment, there is still much room for improvement, especially concerning the modeling, measurement and evaluation of an alignment approach [27].

On the other hand, more importantly, it is hard to combine available approaches and customize them for IT-enabled SSCs. Different aspects of this specific type of supply chain have been studied separately by researchers from various fields. In IS domain, research on IT-enabled SSC stems from service network modeling and design, and has an emphasis on the technological functions and configurations of web services. In operations management (OM) domain, IT-enabled SSC is considered as a special type of SSC and research efforts are drawn from service operations and supply chain management, and the research mainly focuses on exploring the phenomenon on the basis of classic OM and SC theories.

However the alignment of operational performance at different supply chain tiers needs to be achieved through a systematic approach and with comprehensive performance analysis. The scope of IT-enabled SSC falls into the intersection of service operations, supply chain management and information systems (Figure 1.4). That requires an interdisciplinary method that instructs in-depth research on identifying the proper scope and structure of IT-enabled SSCs, as well as on exploring insights into service development, operations and management. The paucity of interdisciplinary solutions to these concerns is the starting point for this research.

Figure 1.4: The interdisciplinary IT-enabled SSC



1.3 Research Objectives and Questions

Given the increasing growth of IT-enabled services, it is time to examine business -IT alignment in this new context. There is a paucity of in-depth understanding of holistic SSC, especially with a focus on the role of IT and IT development in service operations. Moreover, there needs to be an interdisciplinary method that would essentially initiate conversations between the various service stakeholders who together contribute to the delivery of IT-enabled services, and would align their performance in the changing environment with respect to intensive service innovation. Based on its principle objective, this research seeks to answer the following question:

What is an effective method for operational performance alignment in IT-enabled SSC?

The effectiveness of the desired operational performance method is twofold. It should provide means of identifying operational performance gaps in IT-enabled SSC, and generate proper solutions for bridging the gaps that are identified. This leads to the following sub-questions that will help to further direct the research focus and activity:

Q1. What is the state-of-the-art in IT-enabled SSC research?

The first sub-question aims for an overview of current understanding of IT-enabled SSC (Chapter 2) which can be further specified in the following three questions:

Q1.1. What perspectives are relevant in researching IT-enabled SSC?
Q1.2. What is the challenge to alignment in IT-enable SSC?

The answers to these questions lead to the reveal of the knowledge gap in managing the operational performance of IT-enabled SSC and rais the need for developing a proper method to bridge the gap.

Q2. What is a proper research methodology for the development of the method for operational performance alignment in IT-enabled SSC?

The second sub-question is concerned with choosing a proper method in which the research is conducted (Chapter 3). A suitable research approach makes sure that the work presented later is methodologically proven and its findings valid.

Q3. How to design an effective method for operational performance alignment in IT-enabled SSC?

The third sub-question seeks for the construction of the method expected for aligning operational performance in IT-enabled SSC (Chapter 4). In order to answer this question, a set of design goals are presented in terms of specific questions.

Q4. How to validate the proposed method?

The proposed method will be applied into real world cases (Chapter 5 - 7) to discover and bridge operational gaps, to generate added value to the IT-enabled SSC knowledge base (Chapter 8.1) and to assess the shortcomings of the proposed method. Regarding the research objectives, the following criteria are proposed to validate the effectiveness of the proposed method:

Q4.1. Can the IT-enabled SSC studied be comprehensively and accurately modeled?
Q4.2. Can the operational performance issues in the IT-enabled SSC studied be successfully discovered and analyzed?
Q4.3. Can the chosen analytics improve the operational performance issues discovered?
Q4.4. What is the added value to the IT-enabled SSC knowledge base?

The work presented in this thesis focuses on identifying operational performance alignment issues and discovering and assessing their root causes with attention to the dynamics in operating SSCs. This research aims to provide a communication-centered method that can effectively tune and bridge operational performance gaps in IT-enabled SSCs. It is due to the essential role of communication in service operations, for instance in the coordination of business and IT. Misaligned communication is found to be the central issue between business and IT teams during digital transformation [10].

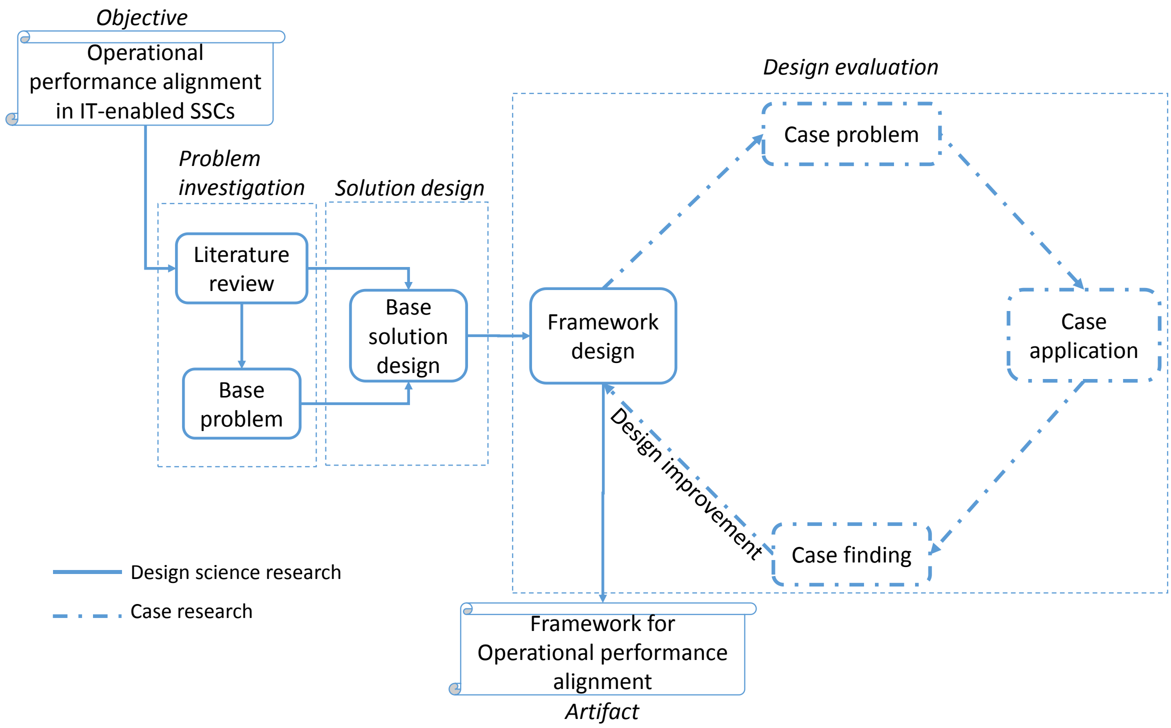
It is worth noting that there is no silver bullet that could eliminate operational performance gaps. Therefore the research effort is paid on bridging them instead of closing them. The desired method should provide guidance on how to collect, organize, and analyze supply chain information, and how to transform the analysis into solutions for supply chain improvement. This method should be operational and tested in real situations. Ultimately this method should benefit IT-enabled SSC managers from both business and technical domains.

1.4 Research Methodology

Because of its objective and the nature of the research questions, this thesis will necessarily adopt a **design-oriented approach to the research** [5] with a systems view of **problem-solving** [28] alongside design evaluation. The approach (Figure 1.5) within which this research is conducted is an synthesis of two research methods of solution-oriented research.

The intention of finding an effective operational performance alignment method for IT-enabled SSC is consistent with the concept of producing artifacts in design science. The designing, building and testing of artifacts in design science research creates knowledge that professionals with formal skills can use to solve real-world problems [29]. The method being sought in this research will be designed, evaluated and implemented in real-world situations, so that IT-enabled SSC managers can adopt it to discover and bridge operational performance gaps. This method is the major outcome and the primary design artifact of this research.

Figure 1.5: Research Approach



The research follows design science research steps to investigate a research problem, design and evaluate a proposed solution. With the objective of researching business-IT alignment in IT-enabled SSC, a literature review will explore and identify gaps in this field. Based on the identified problem and current solutions found in the literature, a framework for business-IT alignment will be proposed for IT-enabled SSC. This framework is the design artifact of this research, and will be evaluated and improved through three case studies.

The design evaluation of the proposed framework employs an iterative process, in terms of **a synthesis of design science research** and **case research**. The evaluation is conducted by applying the proposed framework in three real-world case studies. Every case study is one iteration that includes diagnosing the problem , solving the problem , generating finding and making design improvement. At the end of each iteration, the framework is improved and the new version is applied in the next case study. In every case study, the applied framework explores one specific problem and provides solutions if possible.

Thus this research approach is grounded in a mixture of valid research methodologies. The expected design artifact, namely the business-IT alignment framework for IT-enabled SSC, will be finalized and verified.

1.5 Findings and Contributions

The research presented in this thesis examines the business-IT alignment issue in IT-enabled SSC and makes a modest contribution towards discovering and bridging operational performance gaps in this specific type of supply chain. What this research has advocated with respect to this is to provide an instrument which can modularize complex SSC in terms of a hierarchically-structured set of services and analyze the performance causality between them. With a special focus on the impact of IT, it makes it possible to monitor and tune various performance issues in SSC.

This research intends to provide a solution-oriented common ground, so that multiple service research streams can meet together. Following the framework proposed in this research, services, at different tiers of an SSC, are modeled with a balanced perspective on both business, technical service components and KPIs. It allows a holistic picture of service performances and interactions throughout the entire supply chain to be viewed through a different research lens and permits the causal impact of technology, business strategy, and service operations on supply chain performance to be unveiled.

Operational performance alignment framework for IT-enabled SSC

The design outcome of this research is a verified operational performance alignment framework for IT-enabled SSC. The objective of the framework is to reveal actual problems in the context of IT-enabled SSC, and tackle them in an effective manner. It is oriented towards finding practical solutions. The design of this framework reflects the 'best of breed' manner, which incorporates various modeling and analytical methods across IS and OM research fields in service studies. The framework was applied and tested in three cases at the Dutch telecommunication and ICT service provider KPN.

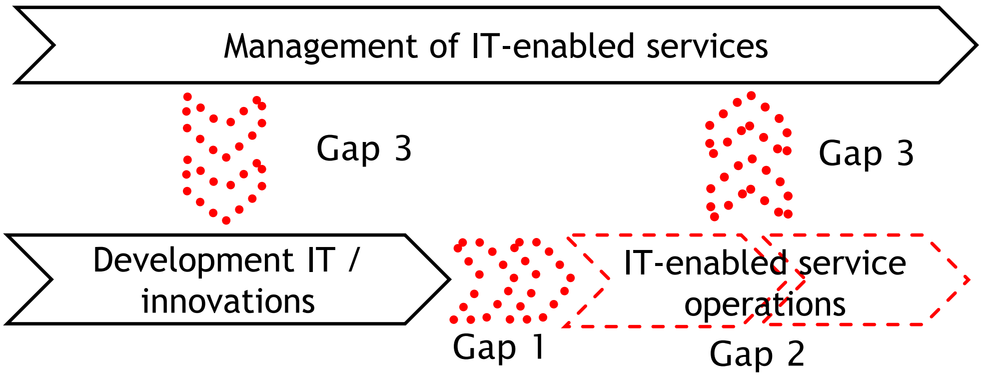
Contribution to the knowledge base of IT-enabled SSC

The importance of IT-enabled SSC to today's service economy and our modern daily life is evident. However the operational dynamics in this specific type of SSC has not been well understood. There is a theoretical knowledge gap when it comes to such understanding. The research presented in this thesis examines the operational performance alignment issue and makes a modest contribution towards discovering and bridging operational performance gaps in the IT-enabled SSC in telecommunications industry.

Complexity of the operational performance in IT-enabled SSC

From applying the above framework in case studies, more insights into IT-enabled SSCs are obtained. The classic business-IT gap cannot be clearly distinguished in the examined cases. It is because IT is found everywhere in this type of IT-driven business. Business and IT are no longer separately operated in IT-enabled SSCs. Instead, there are three other types of performance gaps (Figure 1.6) found at different supply chain tiers, namely the DevOps gap between IT development and service operations (gap 1), the service operations gap in outsourcing environment (gap 2), and the service management gap in coordinating IT development and service operations (gap 3).

Figure 1.6: Performance gaps found in IT-enabled service supply chain



Unique features of IT-enabled SSC

IT-enabled SSC is a specific type of SC that consists of the development, the operations and the management of IT-enabled services. This research confirms that it shares the common characteristics of SSCs, such as the importance of human factor, the continuous provisioning of service capacity, no inventory management but IUS, continuous provisioning of service capacity, inter-connected supply network.

In addition IT-enabled SSC also have unique features due to the critical role of IT applications in service operations. It includes: the impact of IT infrastructure on SSC performance is critical; surrogate interaction is the dominante process region in this type of SSC; human performance is associated with stakeholders' operational knowledge of IT; and there is divergent (technical) domain knowledge.

Contribution of bridging IS and OM to IT-enabled SSC research

The scope of IT-enabled SSC research in IS and OM has been expanded in this research. The framework proposed incorporates different research angles and methods into a holistic and actionable approach. Issues coming from IT development phase (IS domain) and service operations phase (OM domain) have been put together in performance analytics. Balanced emphasis is given on both business and technical aspects of IT-enabled SSC operations. The operational performance of IT-enabled SSC has been assessed from both structural and quality perspectives.

In addition to a holistic scope of including IS and OM research, the combination of design science and empirical research methods also contributes greatly to accomplishing research activities. The framework (Figure 4.6) proposed in this thesis adopts *an explicit modeling approach* from the engineering based IS domain and *a set of analytics* from the social science discipline OM. The development of the framework follows the design science approach, while the design evaluation of the framework is conducted in empirical case studies. The real world cases provide practical environment to demonstrate and validate the framework, and the framework steers the case studies in a structural format.

Contribution to interdisciplinary research

Interdisciplinary research is often considered as a risky path when it is associated with academic careers [30]. Nevertheless spanning academic boundaries contribute significantly to solving complex problems, and the value of interdisciplinary research is increasingly recognized as the modern society rapidly advances with technology development. In this thesis, being interdisciplinary definitely is a feature, not a bug. The research activities carried out present a clear demonstration of interdisciplinary research.

Having a difficult interdisciplinary research demonstrated in this thesis, a few lessons learned can be shared with those who would like to join this inspiring research path. This may be especially helpful to young researchers who just or decide to begin interdisciplinary. These suggestions include:

- Do not claim it interdisciplinary while simply being multidisciplinary
- Let research objectives determine the research methodology
- Clarify the language first
- Be a good coordinator and take lead in the research
- A service oriented mindset is always helpful

1.6 Research Limitations

This research is exploratory, therefore it leaves room for follow-up research. The major concern in relation to the research results, which gives rise to opportunities for future work, comes from the validity of case studies and the ease of use of the proposed framework.

Case studies are used to gain insights into IT-enabled SSC, and to evaluate the business-IT alignment framework that has been designed. The number of cases used in this research (three cases), which is slightly smaller than the ideal number of cases for qualitative research (four to ten cases) [31], still works well to obtain significant detail of one complete IT-enabled SSC. The limitation of the chosen cases is with respect to the design evaluation. All the cases come from the same company in one industry. This directly raises the question of the generalizability of the proposed framework when it is applied in other IT-enabled settings and context.

Another task left for future work is about the level of details in the presentation and specification of the proposed framework. A first concern is the terminology used in developing this framework. The words, service network and service supply chain, are used interchangeably in the framework design and in the other parts of this research. On the one hand this indeed causes confusion for readers, especially people with either a supply chain management background or an information systems background. On the other hand, this proves exactly the paucity of this type of research, hence the bridge of dreams. Within the perspective adopted by this research, both terms are equivalent when referring to the complex environment of providing IT-enabled services.

The proposed framework is well designed and evaluated, however it is still presented with a high level of abstraction. The author prefers to keep the framework in a simple form, as it functions mainly as a 'bridge' between various existing modeling and analytical methods. Thus the design activities focus on validating the structure of this framework, rather than specifying the details of each modeling and analytical method involved. Nonetheless, it is a reasonable recommendation to further specify and customize modeling guidelines when using them in different case settings or environment.

1.7 Reading Guide

The following chapters will further explain the research contents outlined above. First, chapter 2 presents learning from existing work on IT-enabled SSCs. The methodology of this research is explained in chapter 3, and a detailed design of the proposed research approach is given. The design artifact, namely the operational performance alignment method for IT-enabled SSC, is illustrated in chapter 4. In chapter 5, 6, and 7, this framework is applied in three case studies from the Dutch telecommunication and ICT service provider KPN. The contributions of the thesis are discussed in chapter 8. Finally, this thesis is concluded in chapter 9 with discussion on the research method, framework design, and the case studies in the research, and an outline of future research opportunities.

Figure 1.7 shows the overview and connection of all chapters in this thesis, and figure 1.8 depicts the overview of three case studies conducted at KPN.

Figure 1.7: Thesis chapters overview

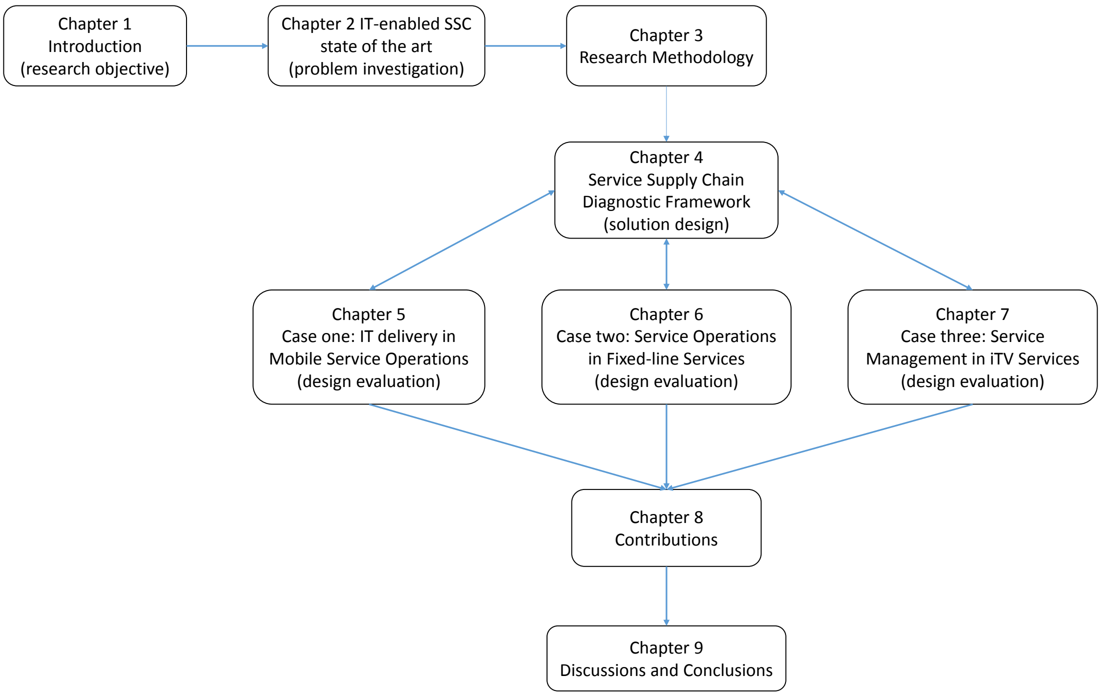
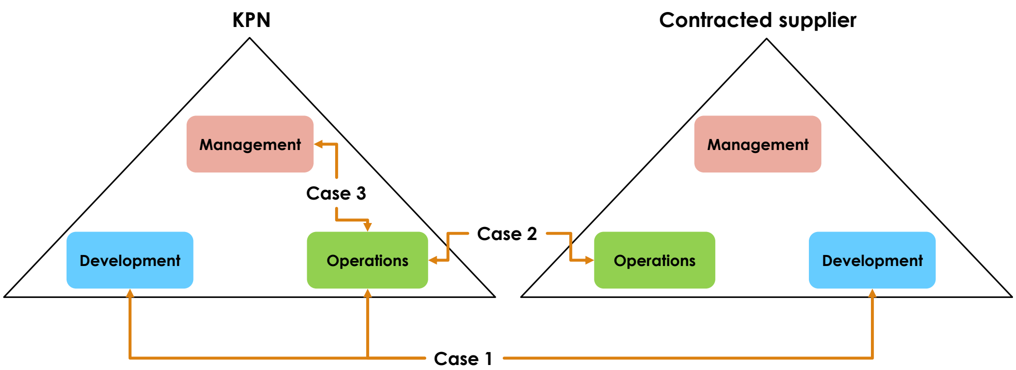


Figure 1.8: Case studies overview



CHAPTER 2

IT-ENABLED SERVICE SUPPLY CHAINS: STATE OF THE ART

This chapter presents a literature review on IT-enabled service supply chain (SSC), which aims to find answers to the following question:

Q1. What is the state-of-the-art in IT-enabled SSC research?

The focus of this review is on the involvement of information technology (IT) in service operations and its impact on the operational performance alignment of IT-enabled SSC. Readers are invited to look into the current understanding of IT-enabled SSC, and will be prepared with sufficient background knowledge and motivations of this research. The current understanding of IT-enabled SSC can be further obtained by answering the three questions below:

Q1.1. What perspectives are relevant in researching IT-enabled SSC?
Q1.2. What is the challenge to alignment in IT-enable SSC?

The rest of this chapter is organized in the following way. It starts with definition and clarification on service related concepts, including a brief introduction of IT-enabled SSC and its interdisciplinary scope (section 2.1). It then looks into each discipline involved in the scope of IT-enabled SSC and introduces the focal issues and leading perspectives in each field (section 2.2 - section 2.4). Then alignment issues in managing IT-enabled SSC are discussed (section 2.5). In the end, gaps in current studies on the operational performance alignment in IT-enabled SSC is concluded (section 2.6).

2.1 Definition and Clarification

2.1.1 Service

It is worth noting that one of the most striking issues, throughout the decades of SOM research, is what constitutes a service [32]. A generally accepted definition of service is still lacking. This is due to the differentiation among organizational levels [33], and on which organizational level researchers put their standpoints. Within the scope of a service organization, at *strategic level*, services are mainly defined as the target service products for customers. At *operational level*, services are often perceived as partial or complete delivery processes of the service product that consumed by customers.

Despite the conceptual variation of services, service are widely accepted as intangible, perishable, inseparable and variable [34]. Services are intangible, because they are performances and cannot be counted, measured, inventoried, tested, and verified in advance of sale to assure quality. The production and consumption of many services are inseparable, since services are co-produced by the customer and provider. The co-production of services implies that service capacity cannot be stored for sale in the future, thus services are perishable. The involvement of various customers in different services indicates that the services are variable from each other.

2.1.2 Service supply chain and service network

A *service supply chain* is defined as a network of interactive service processes [35], where suppliers, service providers, consumers and other supporting units that performs the functions of transaction of resources required to produce services are interconnected, as well as the transformation of these resources into supporting and core services, and the delivery of these services to customers [36].

A *service network* (SN) is considered to be systems of service systems that are open, complex and fluid, accommodating the co-production of new knowledge and services through organic peer-to-pper interactions [37]. Enterprises from different industrial divisions are involved in the SNs, and demand innovative service systems to advance their business in the increasingly complex and dynamic environment [38]. The overall performance of SNs results from a tremendous joint effort at interdisciplinary collaboration, cooperation and coordination among the network participants [39].

SSCs and SNs have a lot in common. They both have a network setting, interpersonal and cross-organizational interactions, are dynamic and rely on joint stakeholder collaborations. The term SSC is often used in operations management (OM) and supply chain management (SCM) where the focus is on service management and coordination, strategies, planning and control. The term SN is the more-frequently used term across several disciplines when modeling is being discussed. In this research, it is legitimate to consider the SN modeling serving fulfilling the same purpose as the objective of this research in relation to SSCs, especially with respect to capturing and aligning different aspects of SN performance. **Therefore the term SN substitutes for SSC in section 2.4 and later in chapter 4, when reference is made to modeling and simulation issues**.

2.1.3 IT-enabled service supply chain

The advances of IT, such as the internet-based technology and the more recent cloud-based technology, has modernized the ways of both service offerings and supply chain management. Beyond productivity enhancement, IT is now playing a far more sophisticated role than ever before in service globalization [40], service innovation [41] as well as business process re-engineering [42]. An *IT-enabled SSC* is the network of IT-enabled services that are deeply dependent on IT applications and its processes are highly automated [21].

Service management is truly a trans-functional research area [43] and attracts research interests from various scientific disciplines, such as marketing [44], supply chain management [45], organizational study [46], and information systems and computer science [47][48]. The scope of IT-enabled SSC falls into the intersection of service operations, supply chain management and information systems (Figure 1.4). It is a specific type of SSC, which integrates perspectives of service operations and supply chain management. The involvement and enabling role of IT in this type of SSC brings information systems closely in relation to the service development and operations. In the following sections, issues in IT-enabled SSC will be discussed from each of these perspectives.

2.2 Service Operations Perspective

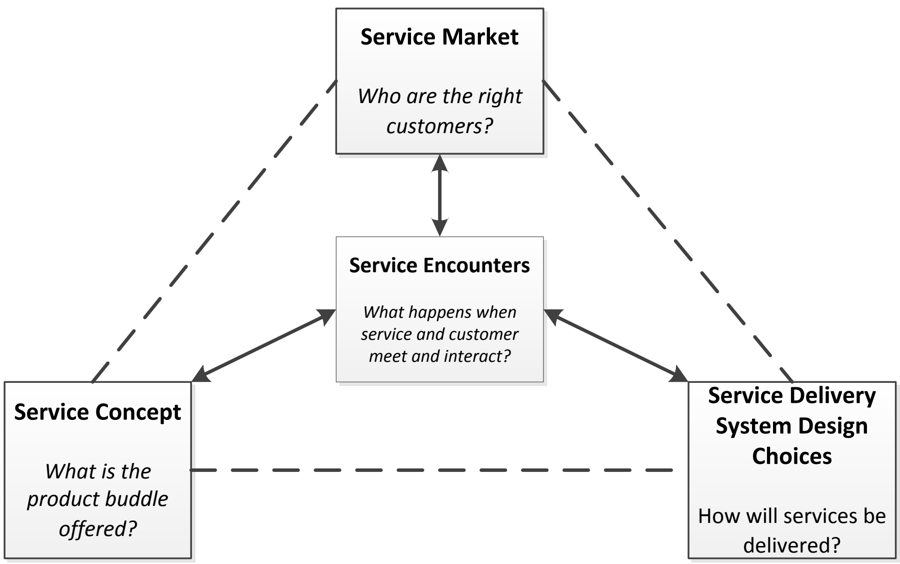
When it comes to the role of service in our economic society, its importance and dominance are well recognized by both academia and industry. The service sector contributes a great deal in modern economies, accounting for more than 50% of the gross national product in countries such as Brazil, Germany, Japan, Russia, and the UK, and making up 80% of the US economy [49]. The global economy has been transformed through agriculture, internationalized industry and entered a service-centric era. Thanks to the Industrial Revolution of the 19th century, an increasing amount of workforce are shifted from the primary and the secondary sectors to the service (tertiary) sector, for instance in transportation, restaurants, hospitality airlines and banking services [50]. Alongside the service economy, academic world started to distinguish services from manufacturing in operations management since 1970s [50].

In the research on IT-enabled SSC, service operations management (SOM) addresses issues on the design and management of services that are delivered to customers. The topics can be grouped into four categories: 1) introduction and key issues of management in services, 2) strategies and objectives, 3) design, and the planning, and 4) scheduling and control. Potentially, research efforts are also paid to 'strategic issues of quality in services' and 'information technology and new technology in services'.

From SOM perspective, research tries to find the theoretical and practical insights that enable firms to effectively conduct operations so that they can offer right services to right customers at right times. This is what has been abstracted in the service strategy triad (Figure 2.1). **Alignment** should be achieved among the target market (service market), the service offerings (service concept) and the service delivery system (service delivery system design choices), all of which together influence the 'moment of truth' when customer interaction takes place (service encounters).

In relation to the taken focus in this thesis, three alignment perspectives can be identified from the service strategy triad: 1) quality perspective; 2) process perspective; and 3) information management perspective. The following sections are structured according to these perspectives.

Figure 2.1: The Service Strategy Triad [1]



Quality perspective

The quality perspective covers the service concept and service market in the service strategy triad (Figure 2.1) and assesses whether the provided services fulfill the right customer needs.

Quality control came into the focus of SOM research in 1980's [50] and has always been vital to the success of service operations. The challenge in controlling service operation quality comes from the difficulty in defining and measuring the exact output of service operations, which is in relation to the intangible services [51]. Concerns about quality in service design, service development and service delivery has been intensively studied by marketing research for over three decades.

Service quality is mainly perceived from three dimensions in Grönroos'model [52]: the functional quality, the technical quality and the corporate image. The functional quality is about how the customer receives the technical outcome, the 'expressive performance of a service'[53]. The functional quality attributes of a service are based primarily on SERVQUAL[54] and include the following five core perceptual dimensions[55]:

- Reliability: ability to perform the promised service dependably and accurately.
- Assurance: knowledge and courtesy of employees and their ability to inspire trust and confidence.
- Tangibles: physical facilities, equipment, and appearance of personnel.
- Empathy: caring, individualized attention provided to customers.
- Responsiveness: willingness to help customers and provide prompt service.

Measuring service quality from the above five dimensions focuses on the service delivery process but does not address the service outcomes. In other words, it considers how the delivery process itself functions from the dimension of functional quality, whilst the service outcome is considered from the dimension of technical quality [56].

The technical quality of a service refers to what a customer receives, the technical outcome of the service delivery process. The image of the service organization that is perceived by customers functions as a filter in the perception of service quality. It is because customers always bring their earlier experience and overall perceptions of the organization to each service encounter, and the corporate image plays a mediating role in one's perception of overall service quality [56]. The Grönroos'model also emphasizes the importance of the provision process (functional dimension) to customers' perception of the service. It is confirmed by Kang and James' findings [56], that the effect of functional quality on image was larger then the effect of technical quality.

It is worth noting that the human factor is of great importance to the quality of service operations. Managing customers and suppliers is critical in supply chain management [57]. Since service value is co-created via intensive interactions between service providers and customers, the service quality perceived by customers is directly influenced by the employee characteristics [51]. Despite the widespread IT applications, intensive human operations and decision makings are still strongly demanded in the highly automated operational processes. Furthermore, it relies on managerial decisions and efficient and effective operations to manage multiple suppliers and information flows in supply chains.

Process perspective

The process perspective refers to the service delivery system design choices in the service strategy triad (Figure 2.1) and helps to check whether the service delivery system is properly designed.

Process-orientation has been one of the main subject areas in operations management [58]. Since 1990s, the concept of business process orientation has been introduced and reported to improve organization performance in terms of faster time cycle, reduced cost, and less duplication of work cross functions [59]. A business process can be viewed from different perspectives: functional perspective, behavioral perspective, organizational perspective, informational perspective and so on [60][61]. Within a business system, different modeling techniques are required to represent one or more of the aforementioned perspectives, and support human understanding and communication, process improvement, process management, process development, and process execution [62].

Process orientation is widely acknowledged and implemented in supply chain management [57]. Business process management focuses on making effective and efficient business transactions and managing relationships in the supply chain by redesigning business processes. Frameworks for managing supply chain processes have been proposed in order to improve the overall supply chain performance.

The close relationship between supply chain management and operations management [63] implies the process nature of SOM research. Sampson [35] visualizes service operations in the Process-Chain-Network (PCN). Services are interpreted in terms of process chains with an identifiable function. Participants that involved in a process are process entities, including producers, consumers, or both. Every process entity has its process domain where a set of steps are initiated, led, performed, and controlled by the process entity. Regarding the degrees of interactions with other process entities, a process domain is distinguished into three regions, where the process entity has direct interaction, surrogate interaction, or independent process (no interaction) with other entities.

A process view is essential for service operations managers to organize service activities, and for technical experts to clarify the cross-functional interactions within service systems.

Information management perspective

The information management (IM) perspective refers to the service encounters in the service strategy triad (Figure 2.1), and facilitates and aligns all the interactions between customers and services.

IM is the application of management principles to the acquisition, organization, control, dissemination, and use of information, and is ultimately concerned with the value, quality and use of information to improve organizational performance [64]. IM is concerned about strategic, structural and operational information-related issues, and relates the information and communication processes and their supporting technology to general business aspects [65]. The demand for IM is driven by the needs for managing information resources within organizations, the development of information technology, and the involvement of information systems and services. Information has always been considered as a primary organizational resource [64]. Among the four constructs related to organizational learning [66], namely knowledge acquisition, information distribution, information interpretation, and organizational memory, three of them are about managing information. The importance and potential research of information are in service operations is well recognized, given the IT-driven globalization of information-intensive services [67].

For service operation studies, IM is called in to help streamlining from two perspectives. This first one is to clarify the confusion occurred during the service delivery process and the interactions between customers and services, and to enhance the information sharing in the service supply chain. Confusion is probably found whenever the same topic is examined across different disciplines, due to the different shoes researchers stand in. The same can be perceived in service related research, due to the discrepancies among the service concepts, the service administrative subjects and the people who care about services [68]. Good recognition and accurate identification of supply chain information can significantly contribute to supply chain performance improvement, which can be realized by an effective information management [69]. Information technology plays a critical role in collecting and utilizing the information across supply chain, so that decision makings and the resulting supply chain performance can be enhanced [14]. Better information sharing technology and willingness to build up information sharing capacity will lead to creative and competitive supply chain collaborations [70].

Another important aspect that IM contributes to service operations is the **alignment between business and ICT**. The documentation of business-IT alignment issue dates back to late 1970s [71] and has been ongoing throughout 1980s [72], 1990s [3] [73], 2000s [74] [75] and till nowadays [76]. The research presented in this thesis will be an addition to the research pool on this topic and takes the perspective of IM. As specified in the adopted definition above, IM is not simply the management of information technology and systems, but always sits between them.

Information is the glue of an organization, and its integrative perspective [65] links business domain and ICT domain from strategic level till operational level. The inconsistency found in the definition of business and IT alignment [76] indicates that attempts on this issue come from different perspectives within organizations or supply chains, including intellectual, operational and cross-domain perspectives. From the perspective of IM, it aims to facilitate the alignment of different domains and at different levels, and to manage hot issues, such as service outsourcing, customer-centric services and so on [65].

2.3 Supply Chain Management Perspective

As services become as the dominating economy due to the increasing customer demand, more and more attention has been paid on comparing SSC with manufacturing supply chain. The role of IT in facilitating supply chain performance has been well recognized in SCM.

2.3.1 Service versus manufacturing supply chain

SSC is distinguished as a specific type of supply chain from the manufacturing supply chain. This implies that there should be some fundamental supply chain characteristics found in SSC, as well as some variations or features uniquely related with services

Common features

Manufacturing and service supply chains share some features in common. For instance they both have high degree of uncertainty [77] and various strategies for performance prediction [78]. Basic issues in supply chain management, such as process coordination across organizations and functions, managing customer demand and relationships, also appear in both types of supply chains.

The commonality is also found in the behavior of both supply chains. The most common one is the bullwhip effect, which is well-known in manufacturing supply chain. It is found to be active in SSCs as well, just operating in a different manner and worse in a service than in a product setting [21]. In manufacturing supply chains, causes of the bullwhip effect are shortage gaming, demand signaling, order batching and price variations [79]. In SSCs, these categories do not, at least not directly, cause bullwhip effects. Instead, the amplification would manifest itself across multiple processes in a service network, and is influenced by 1) the unexpected human capacity consumption in highly automated service processes, 2) the managerial and customer behavior, and 3) visibility and information sharing across the supply chain [21].

Unique features

From the above mentioned commonalities, it can already sense that there are several factors influencing SSCs. Above all, human labor plays a significantly role in service delivery and value creation process in SSCs. Customers are directly involved in many service processes, so that service production and consumption occur simultaneously. The service value is co-created between suppliers and customers [80]. Meanwhile customers play an important role in amplifying the effect of delay in SSCs where they are involved and interact with service providers [21].

Different from manufacturing supply chains, there is not always a clear flow of goods to track in SSC. This is simply because services are so much more complex than products, that their selling points are not focused on the goods but more than that and vary from each other significantly. What has been transferred during SSCs is the service supplier's capacity, in terms of service asset and staff, to its customer in the form of services. Instead of managing goods, a SSC is about the management of information, processes, capacity, service performance and funds from the earliest supplier to the ultimate customer [77].

Subsequently, there is no inventory management for goods. Instead, the role of order backlogs [21] or immediately usable service (IUS) [81] in SCCs is central, as opposed to inventory build-up in product supply chains. This comes naturally that there is nothing to return in services, which is conceptually different from manufacturing supply chains [77]. A good can be returned or exchanged, but a service can not. If a service is not satisfactory at the first time it is offered, it needs rework or additional work to improve its performance. Then it leads to the importance of service capacity in SSCs, which may be drained by rework or unforeseen workload [82].

Service capacity is 'the highest quantity of output possible in a given time period with a predefined level of staffing, facilities and equipment'[83]. The distinction between the manufacturing capacity and the service capacity is that the latter one is about how quickly can ramp up an IUS at a sustainable level, meaning the capacity provisioning is long term and continuous [81].

Furthermore, the supply chain structure in SSCs is more like a network where service organizations and operations are inter-connected. Therefore, the structure of SSCs is often not linear as the one of the traditional manufacturing supply chains [35]. The interactions among involved service providers and customers is spontaneously done [80]. Such SSC structure is dynamic and evolves over time according to changes from interactive processes in the network environment.

Managing SSCs effectively means simultaneously managing capacity, flexibility of resources, information flows, service performance and cash flow management [78]. These core SSC activities are also identified by Baltacioglu et al. [36], who structure the SSC effective managerial activities into demand management, capacity and resources management, customer relationship management, supplier relationship management, order process management, service performance management, as well as information technology management.

Table 2.1 summarized the comparison between service and manufacturing supply chain.

Table 2.1: Service vs manufacturing supply chain

Supply chain features	**Manufacturing supply chain**	**Service supply chain**
Uncertainty	High	High
Basic issues	Process coordination, customer demand and relationship management	Process coordination, customer demand and relationship management
Behavior	Bullwhip effect	Bullwhip effect
Role of customer	End of supply chain	Value co-creation
Product flow	Goods, inventory management	Services and goods, order backlogs or IUS
Capacity	Periodic planning in advance	Long term and continuous
Structure	Tiers	Network

2.3.2 IT in SSC

The advances of IT, such as the internet-based technology and the more recent cloud-based technology, has modernized the ways of both service offerings and supply chain management. Beyond productivity enhancement, IT is now playing a far more sophisticated role than ever before in service globalization [40], service innovation [41] as well as business process re-engineering [42]. Many services and their provisioning supply chains are deeply dependent on IT applications. Innovation on such services is closely associated with or inspired by the advancement of their operating systems.

Service innovation and outsourcing

The type of services evolves over time in accordance with the economic development. The need for different types of services rises as the economy goes through different stages [50], which includes, for instance, the infrastructure services during early agrarian stages, the banking, insurance or other support services when the trade and commerce become mature, or the education service in more recent world economy.

Despite the variety in service contents, service innovation takes place on the following four dimensions in general [84], namely service concept, client interface, service delivery system, and technology. Among these four dimensions, technology is definitely the driving force of service innovation in current time. According to Kandampully[41], the firm's core competency is realized through effective use of internal and external partnerships utilizing technology.

Russo-Spena and Mele [85] reveal the process perspective of service innovation. In their view service innovation is co-creation process within social and technological networks. Service stakeholders that involved in this process integrate their resources and aim to generate mutual value in a collaborative environment. To a more detailed and process-oriented extent, innovation activities are carried out through five co-s interactive processes among stakeholders, namely co-ideation, co-evaluation, co-design, co-test and co-launch.

With respect to IT-enabled services, service innovation is directly reflected in the innovation of the technology itself or the application of technology. Therefore the co-creating innovation process for this type of services has to be put in the context of IT innovation and development, which increasingly takes place in an outsourcing environment.

Outsourcing is an important element in service operations. The rationale behind outsourcing activities is to achieve benefits in terms of cost, operational productivity and product quality by allocating specific tasks to specialized expertise. As recognized almost a decade ago [77], there has been a significant increase in service outsourcing. In particular, the degree of IT outsourcing (ITO), among other professional services, is higher than 80% [86]. IT advances service globalization and specialization, as well as service outsourcing. In SCCs, which are process oriented and structured as a network, service outsourcing is essentially about business process outsourcing (BPO).

According to Lacity et al.[87], regardless of outsourced service content, ITO and BPO have quite some in common with respect to the motivations and determinants of outsourcing outcomes. The main motivations for both ITO and BPO are cost reduction, focus on core capabilities and access to expertise and skills. Furthermore, both types of outsourcing decisions are made with purpose to improve business processes and share concerns for security and intellectual property. When it comes to the outsourcing outcomes, both outsourcing activities are influenced by communication, effective knowledge sharing, partnership view, contract details, culture distance, human resource management and supplier management.

In addition to the commonality with ITO, the business processes within service organizations that can be outsourced can be classified into three groups depending on the extent to which the business process is crucial to the firm [22]. The three groups are core processes which are key to firm success and strategic in nature, critical non-core processes which are important but not one of the differentiators, and non-critical non-core processes which are relatively less critical and can be mostly outsourced. The chosen processes for outsourcing usually require less intellectual property but larger number of people.

IT enablement in SCM

As IT has been increasingly adopted in supply chains [14], the core service operations, i.e. the direct and indirect interactive operations between providers and customers [35], are becoming heavily IT-enabled. Instead of being primarily in support of the business, IT has become the primary business process itself, the core service and also an enabler for business transformation [22].

Most research efforts on the IT-enabled supply chain management (SCM), as classified by [88], are in the areas of strategic planning, virtual enterprise, e-commerce, infrastructure, knowledge and IT management, and implementation. Nevertheless, we need to distinguish the concept of IT-enablement in different contexts. In SCM and OM literature, it is common to see how SCM is enhanced by adopting IT systems [14] [15], where IT is considered as a big accelerator to SCM's efficiency and effectiveness. Other major focuses on the enabling role of IT include how SCM benefits from IT use [16], or the facilitation brought by IT on SC efficiency and collaboration [17]. Among all these research perspectives, IT is naturally important but not a life-threatening element to the business success.

In another context, IT applications make SCC process towards very high level of automation, which leads to the provisioning of IT-enabled services. The three types of technology-enabled services studied in [89], namely internet banking service, telephone bill-paying service, and internet shopping service, are good examples of IT-enabled services. In the case studied by [21], the business processes are highly automated where services do not function without IT. In this case IT is the major enabler and only form to carry out service operations. We adopt the same view, and an IT-enabled SSC is understood to be a SSC in which all operations are fully driven by IT systems.

2.4 Information System Perspective

As clarified at the beginning of this chapter, the term SN substitute for IT-enabled SSC in this section.

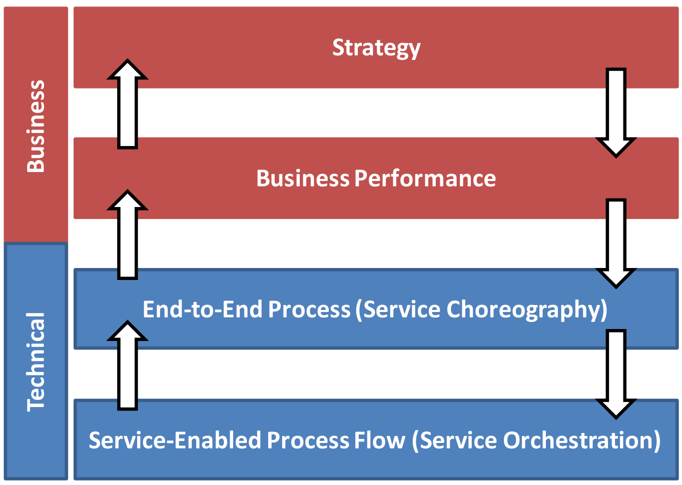
From the perspective of information system (IS), SNs are considered to be systems of service systems that are open, complex and fluid, accommodating the co-production of new knowledge and services through organic peer-to-peer interactions [37]. Enterprises from different industrial divisions are involved in SNs, and demand innovative service systems to advance their business in the increasingly complex and dynamic environment [38]. The overall performance of the SSC results from a tremendous joint effort at interdisciplinary collaboration, cooperation and coordination among the network participants [39].

The diverse aspects of SN have been well studied in different domains. They include the business collaboration among different firms that constitutes the most general form of economically motivated cooperation [90], the software service infrastructure [91], the correlations among the services and network participants which can be viewed as an instantiation of business ecosystem at the time of composite service consumption [92], the networked value chain where the business value is co-created through interactions between the service provider and customer while offering or consuming services [93].

A great deal of work has been done with in relation to different aspects of SN. For instance, strategic management has been widely used to specify the mission of enterprise, and its vision and objectives at different levels [3]. Benchmarking provides a comparison of one's business performance with industry bests [94]. Several promising modeling techniques and tools have been proposed and implemented in specifying the interactions with Web services [95], or simulating the business process [96].

Holistically, SN can be abstracted into a layered architecture (see Figure 2.2), addressing concerns from two main perspectives, business and technical. In particular, it can be divided into four conceptual layers: strategy, business performance, end-to-end processes and service-enabled processes. The SN participants, regarding the specific domain on each layer, could be individuals, a group of people, organizational units or software applications.

Figure 2.2: Conceptual Stack of SN from IS perspective [2]



The strategy layer specifies the networked partners' interests, missions, visions and long-term business objectives, such as market share. Policies and plans are defined to achieve these objectives by launching projects and programs. Resource allocation in implementing the policies and plans, projects and programs is also addressed in this layer. The business objectives specified in this layer are reflected in terms of key performance indicators (KPIs) in the business performance layer. The time frame for planning in the strategy layer is about five years or even longer.

The business performance layer addresses the mutual agreements among the networked partners, defines the expected service level and stipulates the protocols. The performance of the service provision in this layer is measured by monitoring and analyzing the behavior of the projects and programs, such as throughput, employee turnover, cash flow, costs, revenues and return on investment (ROI). This layer's time frame is one to two years.

In the end-to-end processes layer, the partner services are choreographed in compliance with the service level agreements (SLAs) in the actual business process. The interaction protocol between those services is defined from a global perspective across the SN participants. The performance of such service composition is measured by system level indicators, such as *web service response time, availability, security,* etc. This layer's time frame is about months.

The service-enabled processes layer describes the logical sequence and timing of service invocations. Compared with the global perspective, in the end-to-end processes layer which involves multiple participants, the process specified is viewed from the local viewpoint of one single participant. The time frame for dealing with service invocation may be hours, minutes or seconds.

2.5 Alignment in IT-enabled SSC

Alignment is one of the critical issues and catches the eyes of researchers in SSCs, as the fates of all supply chain partners are interlinked [97]. In general SCM, it aims to achieve alignment via coordination [11]. Coordination is the act of managing dependencies between entities and the joint effort of entities working together towards mutually defined goals [98]. This definition is commonly accepted given its generality, while the actual coordination activities are carried from different and more detailed aspects.

For IT-enabled SSCs, one main alignment issue has been, and still will be, the business and IT alignment (BIA). Given the networked setting in SSCs, BIA issue crosses all supply chain coordination (SCC) aspects. Common SCC efforts are put on the supply chain processes, within or cross organizations, the trust and information sharing, the decision making, the partnerships and so on [12].

The classic gap between business and IT is firstly visited and popular alignment approaches are introduced (section 2.5.1). These approaches are further compared and evaluated for SSC alignment (section 2.5.2).

2.5.1 Business and IT Alignment

In the increasingly competitive and dynamic global economy, BIA has been recognized as a key challenge to business growth and success. For over three decades, there has been increasing enthusiasm for BIA issues, which considers the BIA as one of the most important driving forces for business success as well as one of the top concerns by many practitioners and organizational researchers [26]. A good alignment between business and IT helps firms generate more value, reduce wasted resources and perform better. However what actually makes both academics and practitioners have been so keen on this subject is its intriguingly broad scope and the fuzziness in the target alignment [99].

Dimensions in BIA

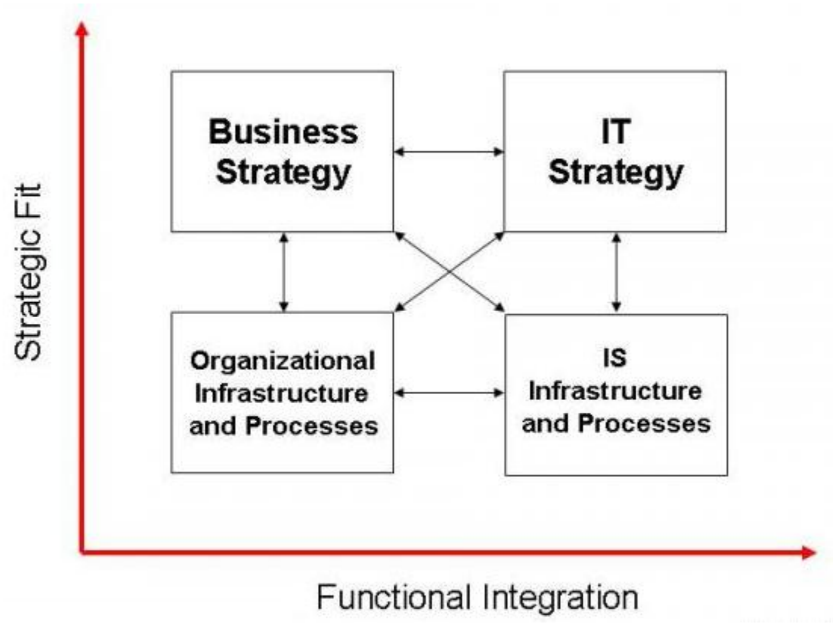
Aligning business and IT can not be done with a silver bullet, but requires a dynamic and continuous efforts to enhance the alignment [75]. The phenomenon of alignment has been interpreted and labeled in various terms [65], for instance, balance [3], coordination [11], fit [100] and linkage [101]. As what could have already been seen, the challenge in BIA even starts from its definition. The inconsistency in definitions of alignment leads to problems for both theory and applied research [76], for instance the confusion among different types of alignment.

Among many BIA definitions, Silvius [99] defines the BIA as the degree to which the IT applications, infrastructure and organization, the business strategy and processes enables and shapes, as well as the process to realize this. This definition implies that BIA measures the state of the alignment and provides methods to reach certain state. In addition it reveals the wide range of BIA issues within organizations, such as plannings, processes, infrastructures and so on.

The Business and IT gap has been pinpointed from different dimensions by both researchers and practitioners. Content-wise the mismatch between business and IT is commonly recognized twofold, namely the 'objective gap' at strategic level and the 'function gap' in integrating business and IT at operational level [102]. Henderson and Venkatraman [3] propose a strategic alignment model (Figure 2.3) to specify these two types of integration between business and IT, namely the strategic integration and operational integration.

At strategic level, the major focus in alignment is on the scope, objective and governance of business and IT [103]. Three different strategies are distinguished, namely information system (IS) strategy, IT strategy and information management (IM) strategy [104]. Being the linkage between business and IT objectives [101], alignment is considered as the effect or resultant state of the IT mission, objectives, and plans sup-

Figure 2.3: Strategic Alignment Model [3]



port and are supported by the business mission, objectives and plans. At operational level, the alignment attention is paid on architecture, process and skills in business and IT domain respectively [103], namely 'how does the organization develop and implement its strategy' [104].

Built upon the above strategic alignment model, [76] further specifies and measures six types of alignment, including the business alignment between business strategy and business infrastructure and processes, the intellectual alignment between business strategy and IT strategy, the IT alignment between IT strategy and IT infrastructure and processes, the operational alignment between business infrastructure and processes and IT infrastructure and processes, and two cross-domain alignments bridging business strategy and IT infrastructure and processes, and IT strategy and business infrastructure and processes, respectively.

Additionally the social dimension of BIA also attracts lots of attention, as distinguished from its strategy dimension, technical dimension and integrated dimension [105]. The social dimension is focused on the human actors and their interactions in the alignment mechanism, and targets the functional integration of human component in the business and IS process to achieve organization's goal [106]. Social improvement is often a long term process. For alignment between business and IT objectives, social factors, such as shared domain knowledge and strategic business plans, demand more attention in order to achieve a long term alignment [105].

Approaches towards business and IT alignment

In order to effectively tackle the BIA challenge, numerous methods, tools and techniques have been proposed. Chen [107] emphasizes the three major approaches that have been done to achieve BIA: alignment via architecture, alignment via governance, and alignment via communication. The research presented later in this thesis focuses on communication to achieve alignment.

In order to provide a better collaborative environment for business stakeholders, Enterprise Architecture (EA)[108], Agile Software Development (ASD) [109] and systems thinking [110] have become popular and have been applied widely to certain extent in practices. In the rest of this section, these three approaches will be compared regarding their visions on architecture, communication and governance respectively. Other BIA approaches, such as goal oriented approaches including the Goal Question Matric (GQM) [111] and the Balanced Scorecard (BS) [112], are out of the research scope.

Enterprise architecture

EA is considered as an effective support for BIA issues, because of its holistic scope that encompasses both business and IT strategies and its architectural descriptions that detail the specifications of every aspects and their relations [108]. Within the domain of EA, it emphasizes on both strategic alignment and architectural alignment. The alignment between the interests of organizational members and IT staff is strengthened, and the architectural descriptions of internal and external enterprise interests provide better path and tool for negotiation [113].

From architectural perspective [114], the alignment is the coherency and consistency of 1) Business Process (BP) and information, 2) BP and applications, 3) applications and information, 4) IT and information, and 5) applications and IT. Practically, the BIA problem can be quantified into three areas: IT system qualities, business qualities, and IT governance qualities. The BIA is influenced by the interactions among these three types of qualities and can only be achieved by adjusting them into an unbiased situation [115].

However, the architectural description of the enterprise's 'As-Is' and 'To-Be' states is a static representation, while enterprises are viewed as systems that continuously evolve through dynamic environment [116]. Thus, EA provides good approach to understand the dynamic perspective of an enterprise, but lacks the ability to predict constant changes.

Agile software development

ASD helps project teams to separate the concerns and to deliver the business value incrementally through interactive development cycles[117]. As emphasized by Wells [118], the actual agility is reflected in the way the development team works that usually includes intensive interactions, dynamic planning (flexible and responsive to changes) and predictable time and capacity allocation. The development team in ASD is light-weighted and follows simple rules in a dynamic environment where changes and new requirements are periodically handled in a new development cycle. The communication between team members is intensive and informal. Daily communication is the major mechanism for business people and IT people to interact with each other.

Neverthelss, ASD process has limited support [119] in challenging situations, such as distributed development environment, subcontracting, building reusable artifacts, development for involving large teams, developing safety-critical software and developing large, complex software. Although time is saved from planning or managing the project onwards, it may be consumed in dealing with immediate problems which leaves insufficient time to development overall strategy and manage performance.

Systems thinking

Systems thinking is a process of understanding a complex system, by understanding how system elements influence each other and examining the impact of their interactions on the overall system [110]. It checks the accumulated system performance as time proceeds, and is commonly adopted as an assisting tool for strategic decision-making [120], alignment [121], design choice [122], or performance management [123]. Its popularity in strategic management [124] comes from their common feature. The core mindset of systems thinking is the interconnections and the influence of relations among all the involved elements. It challenges the traditional object-oriented way of thinking in information system development, by emphasizing the dynamic nature of business requirements and interactions among system elements.

Systems thinking deals with complex feedbacks from other, either internal or external, resources in a dynamic manner. The causality between resources and performance can be measured through the application of System Dynamics (SD), a system-based approach. SD focus on the performance over time, the resource allocation and its driving force on performance, and the resource-building on the basis of existing resources [125]. Systems thinking emphasizes the interrelation and dependency among functioning parts instead of viewing them separately to understand a system or an organization as a whole. Obtaining a system-based mindset allows business and IT professionals to raise the awareness of the dynamic environment: the decision-making and development process is not a static one-time procedure, but is a dynamic iterative process of interactions.

2.5.2 Alignment approaches for SSCs

Each of the above introduced alignment approaches has its pros and cons when being used in practice. The decision on choosing a proper alignment approach for SSCs needs to be made by associating the characteristics of these approaches together with the ones of SSCs. In this section, comparisons of ASD, systems thinking and EA are made regarding different aspects of BIA.

Luftman [74] proposed six components to measure BIA maturity in a more comprehensive manner. The gaps between business and IT are clearly illustrated from the following dimensions:

- **Communications** between business and IT stakeholders.
- **Measurement** of resource consumption and added **value**.
- **Management / Governance** of cooperation between business and IT.
- **Scope & Architecture** design of business and IT collaboration.
- **Partnership** held by all stakeholders regarding their commitments and perceptions of others.
- **Skills** that business and IT staff have for elaborating the collaboration and innovation.

Table 4.3 compares the overall performance of ASD, systems thinking and EA against Luftman's components. The major difference among these approaches is the scope of management.

Communications

All three approaches support communications at different levels. In ASD, daily communication among agile team members is intensive and informal. Knowledge is well shared between individuals directly, but not between different units outside the team. Systems thinking helps to improve communication by revealing the micro-worlds (the process insights). EA shows the big picture, which helps to create shared understanding of existing situation.

Value measurement

The iterative process in ASD leads to incremental business value delivery, so is resource consumption. Systems thinking pays attention on the causal relations between resources and performance, and has quantified measurements for it. On a bigger scale, EA focuses on the overall return on IT investment by aligning it with business need.

Management / Governance

Systems thinking and EA are better for holistic governance. Systems thinking examines the effects of interactions between complex systems and its environment. EA provides full ranges of governance, from business level, organizational level and system level, as well as IT system management capabilities. It ensures all architectural principles and guidelines. ASD, despite of being good at project management, lacks of overall check or control of the total performance.

Scope & Architecture

Each of the three holds different visions regarding this aspect. The main agile principle counts for flexible scope and interactive lean architecture. Systems thinking holds clear vision of organizational direction but is not concerned about detailed scope and architectural design. EA, explained by its name, has holistic scope of whole business and IT, specify business objectives and IT implementation from multiple dimensions.

Partnership

The close collaboration and intensive communication in ASD allow participants to form partnership by having clear perception of each other's roles in specific tasks, although their perception of the overall performance is limited. EA contributes to partnership formation at high level, by generally defining partners' contribution, risks and awards, aligning and protecting partners' interests in negotiations. Although trust and relevant issues can be modeled in system dynamics, there is no strong evidence found that systems thinking helps to forge partnerships.

Skills

All three approaches are found positive in facilitating skills maturity for change and innovation, but to different extents. ASD, still given its scope, focuses on team skills and allows team to response to change and innovation quickly, but within team competence boundary. Systems thinking oversees framework to ensure knowledge management, however only indirectly influence the skill maturity. EA enables organizational ability to changes by establishing consistency and coherence of all enterprise aspect.

Table 2.2: Comparison of BIA approaches

Alignment Component	**Agile Software Development**	**Systems Thinking**	**Enterprise Architecture**

Communications	Intensive and informal daily communication [118]; knowledge is shared through one-to-one communication, however knowledge sharing between different units is not direct [126]	Improved communication by revealing the micro-worlds (insights) [127]	Creating shared understanding of existing situation (big picture) [128]
Value Measurement	Incremental business value delivery [118]	Quantified measurements of the causality between the resources and performance [125]	Increase the return on IT investment by aligning it with business need [129]
Management / Governance	Good for project management, but lack of holistic governance on the total performance [130]	Good for governance by examining the effects of interactions between complex system and its environment [131]	Full range of governance, from business governance to organizational and systems governance as well as IT systems management capabilities, ensure all architecture principles and guidelines [128]
Scope & Architecture	Iterative 'lean architecture' and 'flexible scope' [132]	Clear vision of organization's direction [133]	Holistic scope of whole business and IT, multidimensional specification of business objectives and IT implementation [108]
Partnership	Clear perception of the roles in specific tasks, not from overall perspective [119]	no strong evidence found	General role definition, including the contribution, risks and awards; align and protect partners' interests in negotiations [113]

Skills	Focusing on team skills and responding to change or innovation quickly within team competence boundary [134]	Overseeing framework to ensure knowledge management [133]	Establishing consistency and coherence of all enterprise aspect, enabling organizational ability to change [135]

The environment of SSCs is complex with respect to the customer involvement, the IT-enablement and the outsourcing context (as mentioned in section 2.3). Choosing a proper approach for SSC alignment needs to take these characteristics into consideration when evaluating these three approaches. In general alignment approaches with broader scope, such as systems thinking and EA are comparably more suitable for managing SSCs as a whole. More specifically, EA is both descriptive and prescriptive, which framework is good for structuring information with a holistic viewpoint. Systems thinking provides approaches, such as system dynamics, to dynamically assess the interactions between two or more involved stakeholders. ASD is good at dynamic planning within team competence boundary and controlling planned development, but lack of overall scope at organizational level.

2.6 Conclusion

The studies on the interdisciplinary IT-enabled SSC from multiple research fileds, namley SOM, SCM and IS, have been reviewed in this chapter. The insights and issues that have been covered in this fields still seem to be insufficient to understand the dynamics in the operational performance of IT-enabled SSC. There is a knowledge gap on this subject in current body of literature.

IT enablement has been perceived differently in SOM and SCM, if compared to the one in IS. In SOM and SCM, the enabling role of IT in services is closer to be a big accelerator to the efficiency and effectiveness. In IS, IT-enabled services are refered to web services that are in terms of IT applications. Much of the research into IT-enabled SSC remain as explanatory science in the field of SOM and SCM, while the research in IS field has been conducted separately and even been named differently.

Despite research on identifying performance alignment issues, the challenge of transforming that research into a solution still remains. On the one hand, the challenge comes from a theoretical perspective. Despite the numerous methods, tools and approaches that have been proposed to achieve alignment, there is still much room for improvement, especially concerning the modeling, measurement and evaluation of an alignment approach [27].

On the other hand, more importantly, it is hard to combine available approaches and customize them for IT-enabled SSCs. Different aspects of this specific type of supply chain have been studied separately by researchers from various fields. In IS domain, research on IT-enabled SSC stems from service network modeling and design, and has an emphasis on the technological functions and configurations of web services. In OM domain, IT-enabled SSC is considered as a special type of SSC and research efforts are drawn from service operations and supply chain management, and the research mainly focuses on exploring the phenomenon on the basis of classic OM and SC theories.

CHAPTER 3

RESEARCH METHODOLOGY

The contents presented in this chapter aims to answer the following research questions:

> **Q2. What is a proper research method for the development of the method for operational performance alignment in IT-enabled SSC?**

Choosing a proper research methodology and elaborating a suitable research approach makes sure that the work presented later is methodologically proven and its findings valid. This chapter introduces the research approach adopted in this work, and discusses the methodology behind it.

Let us firstly recall the main objective of this research work: it aims to find an effective method for operational performance alignment in IT-enabled service supply chains (SSCs). The effectiveness of the expected method is assured from two perspectives. On one hand, this method should be grounded in valid scientific methods. On the other, this method should be validated in real-world situations with problem-solving practices.

The search for the expected operational performance alignment method leads to a design-oriented research. The desired level of effectiveness combines multiple research perspectives and draws the best from multiple fields of study. This blends elements of case research in addition to the leading design science research method.

The rest of this chapter initially presents the approach taken to fulfilling the research objective (section 3.1). After that it discusses methodological issues arising in the attempt to synthesize two different research methods, namely design science research (section 3.2) and case research (section 3.3). All relevant design discussions are summarized at the end (section 3.4).

3.1 Research Design

This is an interdisciplinary research that brings the design and empirical oriented research methods. It is driven by the need to examine and align operational performance gaps in IT-enabled SSCs. The expected research outcome is 'an effective method', which will later be proposed as a operational performance alignment framework for IT-enabled SSCs (Chapter 4). This suggests that the research is **design oriented research** [5] in nature, and takes a systems view of **problem - solving** [28] alongside the design evaluation. The approach (Figure 1.5) taken in this research is a synthesis of two research methods in solution oriented research.

This research intention is consistent with the concept of producing an artifact in design science. The design, building and evaluation of artifacts in design science research creates knowledge with which professionals can use formal skills to solve real-world problems [29]. This research follows **design science research steps** to **investigate** a research problem and **design** and **evaluate** a proposed solution.

Regarding the context of researching operational performance alignment in IT-enabled SSC, relevant works are reviewed in order to explore literature gaps on this issue. Based on identified problems and current solutions in existing works, a framework for operational performance alignment is proposed for IT-enabled SSC. This framework is the design **artifact** of this research, and will be designed and evaluated through an iterative development in terms of case studies.

The design evaluation of the proposed framework employs an iterative process, in terms of **a synthesis of design science research** and **case research**. The evaluation is conducted by applying the proposed framework in three real-world case studies. Every case study is one iteration that includes diagnosing the problem , solving the problem , generating finding and making design improvement. At the end of each iteration, the framework is improved and the new version is applied in the next case study. In every case study, the applied framework explores one specific problem and provides solutions if possible.

The methodology will be explained in the next sections in terms of the principles and research model pertaining to each of the research method involved.

3.2 Design Science Research

Design science is about creating knowledge in order to fulfill human needs. The match between design science research (DSR) and the research in this thesis is found in two main aspects, namely the solution orientation and knowledge creation.

Design science brings solution orientation to management and organization studies

DSR is foundational to the discipline of information systems, as it provides new and innovative artifacts to extend the boundaries of human and organizational capabilities [29]. Differing from formal science (e.g. philosophy and mathematics) and explanatory science (e.g. natural science and a major section of social science), the engineering roots of DSR indicate that the research in design science is solution-oriented, connects theory and practices, and uses a scientific approach to search for resolutions to practical problems [136].

But the range of design science definitely goes beyond its roots and crosses different academic disciplines. From the guidelines proposed by Hevner et al. [29], it is clearly shown that conducting DSR in information system requires knowledge and resources from both technology-oriented and management-oriented fields. In addition to engineering disciplines, such as architecture or systems engineering and so on, design science also contributes to organization and management studies.

As most research on management is based on an explanatory science paradigm, it is often criticized for the lack of relevance to practice, in other words, the utilization problem. There is a gap perceived in management literature between the academic and the professional reputation systems [137]. For instance those management theories devised with scientific rigor may not be so useful in practice. What design science can contribute to this type of research is to add field-tested and grounded design propositions. The knowledge developed in design science is for professionals who are capable of solving real-world problems with formal skills. In addition to producing explanations for research problems, design science brings tested and grounded technological rules to the field of management. A technological rule is defined [136] as a chunk of general knowledge linking a particular intervention or artifact with a desired outcome or performance in a certain field of application.

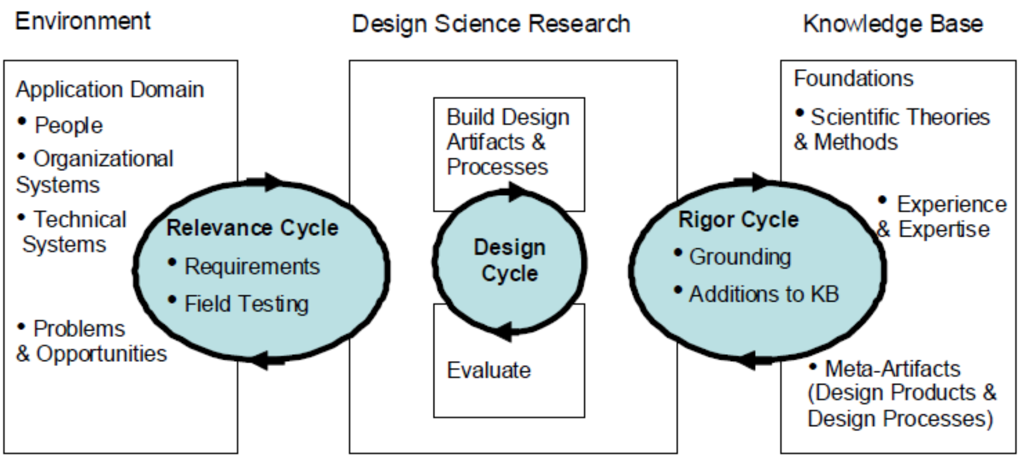
Management study is more context dependent and evidence-based, while DSR results in professional knowledge relating to general solution concepts for a class of problems. This marks the role of knowledge at different levels critical to field success in management and design science respectively. Having said this, if organization and management study makes use of the solution orientation of DSR, more specifically the generality of design propositions produced by design science, its problem of relevance can be mitigated and research results can be used to greater extent [138]. Organization study is significantly influenced by behavioral science but is meanwhile engaged with a field problem. A design science perspective can provide an additional focus on the design and learning elements of planned change projects, as well as draw attention to performance improvement that combines business and humanistic values [139].

The research in this thesis is exploratory, since it explores operational performance alignment issues in IT-enabled SSCs. But in addition to that, and more importantly, it also aims to bridge them. The knowledge generated from this research should be able to be used in designing an effective framework to solve underlying problems (section 1.2). DSR has the same solution-oriented type of mission and outcome. If the mission of DSR is to develop knowledge for the design and realization of artifacts, or to be used in the improvement of the performance of existing entities [136], the outcome of DSR could be three types of things, viz. the objects in terms of interventions, the realization plan for intervention implementation or artifact building, the problem-solving process or the design method. These three things can be easily linked to the three types of artifacts differentiated by March and Smith [140], viz. the constructs, the models, and the methods.

Design science connects multiple perspectives for knowledge creation

DSR encompass both theory and practice, its scope is often an iterative process across three closely connected cycles of activities (Figure 3.1), namely the relevance cycle, the design cycle, and the rigor cycle [4]. The relevance cycle connects the practical environment of the research problem (such as people, organizational systems, technical systems, and problems and opportunities) and the design science activities, while the rigor cycle links the design science activities with the knowledge base of the research problem (such as scientific theories and methods, experience and expertise, and meta-artifacts). The design cycle, sitting between the relevance cycle and the rigor cycle, iterates between artifact development and evaluation. The research environment provides requirements of the desired artifacts and is where the field testing of the artifact takes place. The design activities should be grounded in the knowledge base, meanwhile the novel information captured from artifact design and evaluation could make a theoretical contribution to the knowledge base, or may even form the basis of new theories [141].

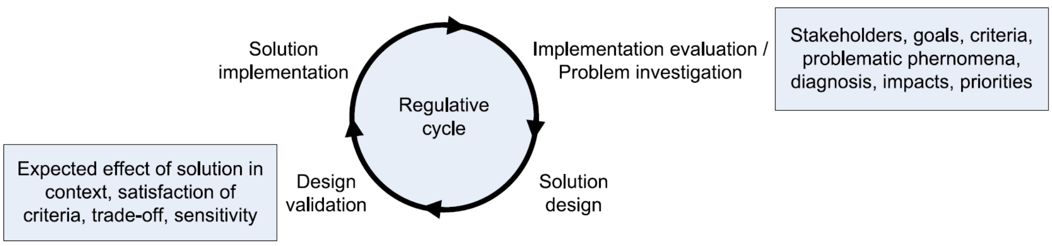
Figure 3.1: Design Science Research Cycles [4]



Serving the purpose of problem solving, DSR, as mentioned in [5], is also often conducted following a regulative cycle [142]. The regulative cycle (Figure 3.2), with its origins in psychological practices, is a general structure of the rational problem solving process. Steps in this process include problem investigation, solution design, design validation, solution implementation, and implementation evaluation.

The regulative cycle connects different perspectives taken in the general design science research cycles. It starts by collecting information and understanding domain problems from the **environment**. In this way possible future change to the problem context is grounded in the existing **knowledge base**, and specified in the **design science research**. The designed solution needs to be tested in the field to see its effects on the problem context, a slightly different context, and the trade-offs, before the design is implemented to actually solve the problem.

Figure 3.2: The Regulative Cycle [5]



Given the research context of this thesis, knowledge creation can be greatly steered by this regulative cycle. The activities in the research interact intensively with both the environment and the knowledge base. The research problem is identified from the gap between existing work on operational performance alignment (knowledge base) and the alignment issue in IT-enabled SSCs (environment). The design of the solution incorporates various modeling and analytical methods across several fields of service studies (knowledge base) in a 'best of breed' manner, and is tested in 3 real situations (environment) for validation and improvement.

3.3 Case Research

Empirical evidence is vitally important in evaluating a design, since the design should reflect the reality of the situation. In this research, the expected design of the framework should be capable of receiving all possible input even under extreme conditions, and producing plausible output that can pass through generalized test conditions. Real-world case studies suit such requirements best in shaping and validating the proposed operational alignment performance framework for IT-enabled SSCs.

Studying cases to explore and explain empirical evidence

Case study, among other empirical methods, is the most frequently chosen research method in operations management research[143]. Case study should be considered when one or more of the following conditions [144] are met, (a) the research seeks answers to 'how' and 'why' questions; (b) the behavior of those involved in the study cannot be manipulated; (c) the contextual conditions are relevant to the phenomenon under study; (d) the boundaries between the context and phenomenon are not clear.

The purpose in using case study in this research is to provide empirical evidence to evaluate the designed framework. The expected empirical evidence is made up of two parts, in terms of the implementation of the designed framework and the exploration of operational performance alignment in IT-enabled SSCs. It is also necessary to determine suitable types of case studies [145] that will meet the purpose of the study.

With respect to providing evidence about framework implementation, the case studies conducted are **explanatory** because they demonstrate how the designed framework should be applied in a real setting and how it can discover, analyze and bridge operational performance gaps. With respect to providing evidence about operational performance alignment exploration, the case studies are **exploratory** and **descriptive**. When implemented, the designed framework explores and describes operational performance gaps and supply chain insights into IT-enabled SSCs.

Furthermore, the case research conducted is also a **multiple-case study**. Multiple cases enable researchers to explore differences within and between cases [144]. Implementing the framework in multiple cases tests its generalizability. Exploring operational performance alignment issues in different cases compares different settings and gaps in IT-enabled SSCs.

Instructing design evaluation from case research's process model

Research activities in case research are generally carried out in a five stage process model (Figure 3.3).

Stage 1 Define the research question
: The field environment is often real and complex, which requires a very observational lens to fully understand and discover field phenomenon, in other words, to find out what problem really needs to be tackled.

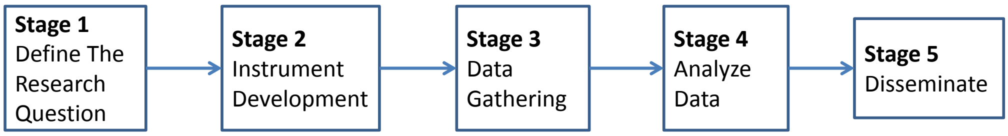
Stage 2 Instrument development
: After the research questions are defined, a case study also needs to be conducted with careful 'design', a stage known as instrument development. The instrument of choice for case study is the study protocol, including principle documentation with a clear case focus, valid case measurements, and proper case site selection. Case selection needs to be appropriate with respect to research objectives [31].

Stage 3 & 4 Data gathering & analyze data
: Collecting case data is the initial stage in applying the designed instrument and is followed by analyzing and interpreting what is hidden from those data. Both data gathering and analyzing needs to deal with the issues of bias and of trust between the researchers and interviewees. Close and detailed observations, triangulation, careful determination of cause-effect chains, and logical reference need to feature in case studies in order to conduct rigorous and competent research [146].

Stage 5 Disseminate
: In the end, case research needs to be properly incorporated in the research objectives and, for publication, should be incorporated in journal articles. The findings from case studies are often criticized from different viewpoints. There have been concerns about the validity, reliability and generalizability

of tge case study being a scientific method in social science. It is true that, on one hand, generalizing content-independent theory from case studies is difficult. On the other hand, content-dependent knowledge is more valuable for research that deals with human affairs [147]. Case study is preferable for new theory development, selective testing of existing theories in particular circumstances, and extending existing theories in situations that require deep field understanding [146].

Figure 3.3: The five stage research process model [6]



The design evaluation phase in this research is an iterative development process in terms of three case studies. The iteration of design evaluation, from a case research perspective, involves conducting multiple case studies. The above linear process model is integrated into one cycle of design evaluation, and instructs the evaluation at case level. As depicted in the design evaluation approach in Figure 1.5, every case study includes a case problem (stage 1), a case application (stage 2, 3 4), and a case finding (stage 5).

3.4 Summary

This chapter has introduced the design science based research approach of this thesis, including the problem investigation phase, the solution design phase, and the design evaluation phase. The design evaluation phase is a synthesis of four research methods, namely DSR, process research, case research and AR.

The reason of choosing this methodology to approach this subject lies in the objectives of this research and the characteristics of each research method involved. The expected outcome of this research is an effective framework for operational performance alignment in IT-enabled SSC and this is consistent with the concept of producing artifacts in DSR. In addition, the solution orientation and combination of multiple perspectives for knowledge creation in DSR fit very well with the objectives of this research.

The practical environment comes from studying real-world cases, where concrete problems are discovered and solved. This is why case research is chosen in the design evaluation phase. Real-world settings of IT-enabled SSCs provide empirical contents for the application of the designed framework. Based on incremental development through case studies, the designed framework is validated as a generic knowledge contribution to professional worlds.

CHAPTER 4

SERVICE SUPPLY CHAIN DIAGNOSTIC FRAMEWORK

The contents presented in this chapter is the answer to the research question:

> **Q3. What is an effective method for business-IT alignment in IT-enabled SSC?**

This chapter presents the construction of a framework for diagnosing the operational performance of service supply chains (SSCs). This framework is the base solution which is referred to the solution design phase in the research approach (Figure 1.5 presented in Chapter 3.1). By following the procedure in the proposed framework, users are able to collect, structure, generalize and analyze the performance information of complex SSCs. Eventually, the resulting analysis should be able to provide effective suggestions for performance improvement.

The framework design is driven by *three design goals*, namely the **clarity of terminology**, the **state-of-the-art modeling and simulation approach** and the **best-of-breed framework composition**. It starts with clarifying basic concepts and components in service and service performance (section 4.1), in order that a multi-disciplinary perspective may be seen in this proposition. The term 'service network' (SN) is used in designing the framework (section 4.2), and is considered equivalent to SSCs. The term SN is the more-frequently used term across several disciplines when modeling is being discussed in the same way as SSCs are discussed in this research. The complete framework is introduced (section 4.3), and the outlook for design evaluation is illustrated at the end (section 4.4).

4.1 Clarity of terminology

The framework expected should premise on clear terminology. The definitions and contents of service vary in the eyes of stakeholders from different service domains. In general, services are intangible, heterogeneous, inseparable and perishable, and they provide something of value to those who know how to request and consume them, without having to know how to produce that value. However the term 'something of value' has significantly different meanings in the business world and in the IT world.

This design goal is achieved by answering the question:

> **Q3.1. What are the core concepts and components of IT-enabled SSC from different research perspectives involved?**

4.1.1 Confusions in Shared Service Terminology

Service science [148] is an expanding interdisciplinary field of study of complex services, and the design and implementation of service systems. When looking into the literature on service science, it is easy to become confused by the way in which shared terminology is interpreted by different research communities. The implementation of Service Oriented Architecture (SOA) is considered able to align business and IT in a service delivery process. However the term 'Service Orientation' causes some confusion among the business and technical parties that are involved in the same SSC, to a greater extent than they are aware. It is common to encounter different interpretations of concepts, such as service, among business owners, software vendors, application providers and more.

We present in Table 4.1 a comparison of different perceptions of the most fundamental concepts that are shared in service science as understood by economics/marketing and service computing research communities. It is clear that the shared service terminology has different implications for business science and computer science respectively because of the fundamental distinction in the definition of service made by these two domains. In business science, a service is an economic activity in which people are the major participants and perform the key interactions with each other. In computer science, it is not necessary to involve human operation in carrying out a service.

It is important to mention that, both business and technical worlds recognize that there are different types of services and tend to expand their visions in the service provisioning processes. However, they cannot reach agreement in defining business service and technical service, because of the inherently different

Table 4.1: Shared Service Terminology in Business Science and Computer Science

	Economics / Marketing (Business Science)	**Service Computing (Computer Science)**
Service Orientation	Service-Dominant Logic: an alternative view of economic exchange and value creation [44];	Design paradigm for separating concerns in building computer software with a suitable technology platform [149];
Service	An application through deeds, processes and performances [150], which includes all economic activities whose output is not a physical product, and provides added value that are essentially intangible concerns of its first purchaser [151];	Individual units of automation logic that conform to a set of principles that allow them to evolve independently, while maintain a sufficient amount of commonality and standardization [149];
Service System	Value co-creation configuration of people, technology, value propositions and shared information [47];	Software application, business unit or composition of service systems within and/or cross organizations [152]; Socio-technical system [38];
Service Network	Business networks that constitute the most general form of economically motivated cooperation among different firms [153];	A semantic relation based Web service infrastructure [91];
Business Service	Business activities provided by a service provider to a service consumer to create value for the consumer [90]; A specific set of actions performed by an organization [46];	The most fundamental building block that encapsulates a distinct set of business logic within a well-defined functional boundary [149];
Technical / IT Service	Technical support, an activity or process of providing technological assistance [154];	Software service describes part of an application system that can be reused and composed based on business needs [155];

scope of their interests. We have learned that SSC participants from different domains may be involved in the same service and communicate intensively. This demands extra attention to service categories while studying SSCs. .

4.1.2 Service categories

Given the mixed types of services found in SSCs, a service taxonomy is very helpful in differentiating the characteristics of different types of services and identifying the key drivers for successful development. There are several service taxonomy propositions from various perspectives, and each has its own focus with specific goals. Chen et al. [156] develop a business service taxonomy for business service innovation and take into consideration the degree of client interaction and the degree of standardization. Bieberstein et al. [157] classify business services according to their strategic importance and organizational ownership.

When coordinating the components of enterprise architecture, services can be categorized into process service, capability service, core service, utility service and Infrastructure service [158]. Sithole et al. [159] categorizes software services on the base of service functionality, relationships, interface and run time properties, deployment, and execution strategies in order to derive performance components from the service taxonomy.

As shown in Table 4.2 [160], from a business perspective human operations form the major activities in service provisioning, and are strongly connected with each other via the consumption of technology, shared information and value propositions. Customers are heavily involved and have a strong influence on the stakeholders' decision-making on capacity allocation. On the other hand, from an IT perspective the major focus is the functional construction of services. The services mainly appear in the form of software applications or are enabled by technological capacity. The business logic is considered as a target instead of an enabler.

Table 4.2: Perceived services in business and IT worlds

Element	**Business world**	**IT world**
Participants	People	Software application
Major activity	Human operation	Functional construction
Resource	Personnel capacity	Technical capacity
Production	Value for the consumer	Reusable functions

4.1.3 Service quality

It is impossible to leave the quality issue alone when dealing with service performance, especially when the objective here is to seek a way of improving the performance of SSCs. Regarding the elusive nature of quality, service quality, at its core, means different things to specific service stakeholders. From a business perspective, service quality centers on customers' perceptions of the services and of the firm offering the service. Customer satisfaction is concerned with the difference between the service quality they expect and their perception of the service they get. The mismatch between expectations and perceptions affect the experience of service quality. Grönroos emphasizes the functional quality, technical quality and the corporate images of a given service as important components in his service quality model [53]. Quality gaps can be found at different tiers of an SSC, including the service provisioning process, the outcome of the service provisioning and the image of service providers [161].

From an IT perspective, services are to be found in the form of pieces of software. The quality attributes mainly focus on both functional and non-functional aspects of software services, such as service response time, availability, accessibility, security, adaptability, cost and so on. Different quality models of software services come from fields such as software engineering, service-oriented computing and business process management, and cover both atomic and composite quality attributes of software services [162].

As a major measurement of service quality, the service performance expected also varies depending on the concept of quality held by service stakeholders. A performance gap occurs when the perceived service does not behave well enough to meet service goals. In complex SSCs, performance gaps have their roots in different aspects of service provisioning, such as strategic management, business performance management, business process management and IT service implementation and operation etc. The overall performance of an SSC relies on harmonious joint efforts from all of these different inputs. In order to align SSC performance with all the relevant aspects, we turn to modeling and simulation to propose a solution.

4.2 State-of-the-art SSC Modeling and Simulation

The information contained or being processed in a complex SSC is usually on a massive scale. Every SSC stakeholder holds a unique view and forms an information source in the supply chain. It is fair to say that there are seldom stakeholders who share the same holistic picture about the same supply chain that they are involved in. Therefore the challenge in diagnosing SSC performance actually lies in collecting and interpreting the chain performance information.

Modeling in general is a way of communication that aims to show a part of the real complex world in an abstract but essential representation [163]. In service science, service network modeling, simulation and optimization has been one of the top priorities. In the context of this thesis, modeling and simulation are relied on to reveal the essential SN elements and clarify the complexity of SSC performance.

Therefore the state-of-the-art SSC modeling and simulation is on demand, and a concrete questions is raised:

> **Q3.2. What are the current modeling and simulation approaches in IT-enabled SSC?**

4.2.1 SN modeling attempts and simulation

SN modeling attempts

Several attempts at modeling SNs have been taken into consideration in this research. IBM's service-oriented modeling and architecture (SOMA) ([164]) introduces a modeling life cycle of service identification, specification, realization, implementation, deployment and management. Its major building blocks include services, service components and process flows where a service component is composed. The Service-oriented modeling framework (SOMF) ([165]) is designed for software service development, and proposes a 'holistic' modeling language that could be used for various modeling environments, such as application, technology and business.

Danylevych et al. [48] view the SNs as being built around software services and propose a formalism for modeling SNs at instance level in order to model concrete SNs. Their modeling focuses on the business relationship between the network participants and their exchange of software services. The SNs model is formed with three core elements, namely the network participants, the service requests and offerings, the business relationships and service providings.

Given a bigger scope, S-cube project [166] proposes some SNs modeling concepts at metamodel level based on a consideration of both business and IT perspectives, such as Service-Dominant Logic, value network, SOA and BPM. The purpose of providing the modeling at metamodel [1] level is to transform the SNs model into a business process model, so that it can bridge the gap between tools and concepts. In the metamodel, SNs consist of business entities and services that are exchanged between those entities. A business entity can be instantiated into end customer, enabler (intermediate provider), participant (provider), or service sub-network.

Focusing on the organizational integrations in SNs, social network analysis (SNA) has also been adopted as an appropriate method of visualizing SNs [168], with its emphasis on the social relations among the organizations in SNs. The key

[1] A metamodel is a model of a modeling language. The metamodel defines the structure, semantics and constraints for a family of models [167].

elements under consideration through the SNA lens include the structural properties of network social relations, and the descriptions of those properties.

The standpoint and purpose of SNs modeling determine the modeling level and the core network elements. Resulting from research and evaluation of current SNs, this SNs research chooses to focus on the distinction between business and software services in the SNs. It also focuses on the impact of multi-level network interactions on SNs performance, given that the modeling goal is to reveal essential SNs information for performance modeling and simulation. We view the **service participants**, the **capacity (both personnel and technical)** required in service operation, and the **service association** in the network structure as the core elements.

Simulation Paradigms Comparison

In the inter-organizational service provisioning process, service performance is determined and changed through interdisciplinary interactions across multiple SN layers. To capture and measure the fluid SN performance, a dynamic modeling approach, viz simulation, suggests itself.

Over the years, simulation has been recognized and extensively studied as a powerful, rigorous yet practical suite of methods and tools that helps to analyze and predict the qualitative and quantitative aspects of service systems. Simulation helps to better understand and manage not only the service systems at large, but also the processes that embody them and their supporting information systems. Thus simulation allows us to iteratively discover, define, refine and improve our knowledge of the principles and laws of such systems, and make more informed and accountable decisions.

There are three mainstream paradigms in simulation modeling, namely Agent Based (AB), Discrete Event (DE), and System Dynamics (SD), all of which have been widely used in various areas including business, supply chain management, healthcare and urban planning [169].

* **AB** modelling simulates the operation and collocations between autonomous agents. While each agent has their own individual perception and incomplete information of an end-to-end process, they are able to communicate and share information with other agents. The behavior of an agent is defined by its internal state, which is a cognitive structure that determines what action the agent takes at time t, give its perception of the environment [170].

* **DE** modelling analyzes system changes after a specific time interval or incoming event where between any two events/time intervals the service system remains stable. DE models are defined in terms of entities, resources and block charts describing entity flow and resource sharing [169]. In DE models, entities (e.g. people, tasks or messages) passively travel through the block of flowcharts, where they could be delayed, stopped, processed, etc.
* **SD** entails 'the study of information-feedback characteristics of industrial activity to show how organizational structure, amplification (in policies), and time delays (in decision and actions) interact to influence the success of the enterprise' [171]. In its basic form, SD analyzes feedback loops and the emerging behavioral effects, such as exponential growth or decline, that result from them. SD models populations as discrete actors and conceptualizes processes in terms of aggregated stock and flows and constraint information. Stocks are the accumulation of resources at different states in the processes, which can be material, people, money and so on. The flows connect the stocks and provide the channel for transporting objects from one stock to another one. The moving rates are determined by the constraint information which comes from the system capacity and business strategy.

Finding a 'one-size-fits-all' simulation solution for SNs is not a practical remedy. The major three vary in terms of their characteristics, abstraction levels and modeling focuses (Table 4.3). The abstraction levels are from low to high, from operational level to aggregated level. DE and AB mostly work in discrete time, and SD mainly models continuous processes. DE views the process dynamism in terms of the occurrence of sequential system events, while AB pays attention to the autonomous individual behaviors in a system. SD models the causal relations and feedback loops among the system elements, and focuses on the impact of the elements' interactions on the system behavior.

Table 4.3: Simulation Techniques Comparison

Simulation paradigm	**Modeling focus**	**Abstraction level**	**Characteristic**
System Dynamics	Causal relations and feedback loops	Aggregated level	Continuous nonlinear process
Agent-based	Individual behaviours	Individual level	Discrete nonlinear process
Discrete Events	Sequential system events	Operational level	Discrete linear process

4.2.2 Systems thinking in SN

Systems thinking is a process of understanding a complex system, by understanding how system elements influence each other and examining the impact of their interactions on the overall system. Its application in service systems is not new. With the ability to analyze the feedback effects, systems thinking has been suggested for strategic business planning for network services [172], and applied in reference architecture [92] for capturing the dynamism of complex system and continuous system optimization.

Service systems are essentially socio-technical systems. As researched in [173], human provided services and software services are strongly interrelated and influence each other in large-scale enterprise service networks. Systems thinking also addresses the interrelations between the technical and social parts of systems [174], and this can be used to tackle the challenges, such as determining the relations between human and non-human participants and the coordination and composition of the network services.

Based on the comparison in chapter 4.3, **systems thinking is considered as the steering mindset** that keeps our scope at a holistic SNs level and makes us aware of the relationship between and the influence of the network elements. In particular, the SN is viewed as a socio-technical system, while the key elements of this system are the services consumed in the network including both business and technical services.

4.3 Best-of-breed framework composition

The third design goal is to employ a best-of-breed manner in constructing the framework. The intention of this framework design is not to invent new modeling or simulation method, but to make best use of existing ones. On the basis of achieving previous two design goals, the tasks according to this design goal is to find answers to the following questions:

> **Q3.3. How to model the core components of IT-enabled SSC for operational performance alignment from interdisciplinary perspective?**
>
> **Q3.4. How to generate the operational performance measurements of IT-enabled SSC?**
>
> **Q3.5. What analytics can be used to discover and improve operational performance issues in IT-enabled SSC?**

In this section, the base solution (Figure 4.1), otherwise known as the service network diagnostic framework[2] is presented. With the purpose of bridging the performance gaps in innovation-driven SSC, the design of this framework consults action research (AR) for the purpose of solving practical problems. The essential two-stage process in AR [175], namely the diagnostic stage and the therapeutic stage, is adopted in the base framework (Figure 4.1).

The diagnostic stage (section 4.3.1) begins with triangulation of data collection. An SN metamodel is designed for structuring the collected data. Based on the modeling, a group of SN performance components are generated and explained. The specific approach in therapeutic stage (section 4.3.2) is driven by a systems-thinking mindset, and may optionally include the analysis and simulation of service performance causal relations.

4.3.1 Diagnostic phase

The contents presented in the section is the answer to the following research questions:

> **Q3.3. How to model the core components of IT-enabled SSC for operational performance alignment from interdisciplinary perspective?**
>
> **Q3.4. How to generate the operational performance measurements of IT-enabled SSC?**

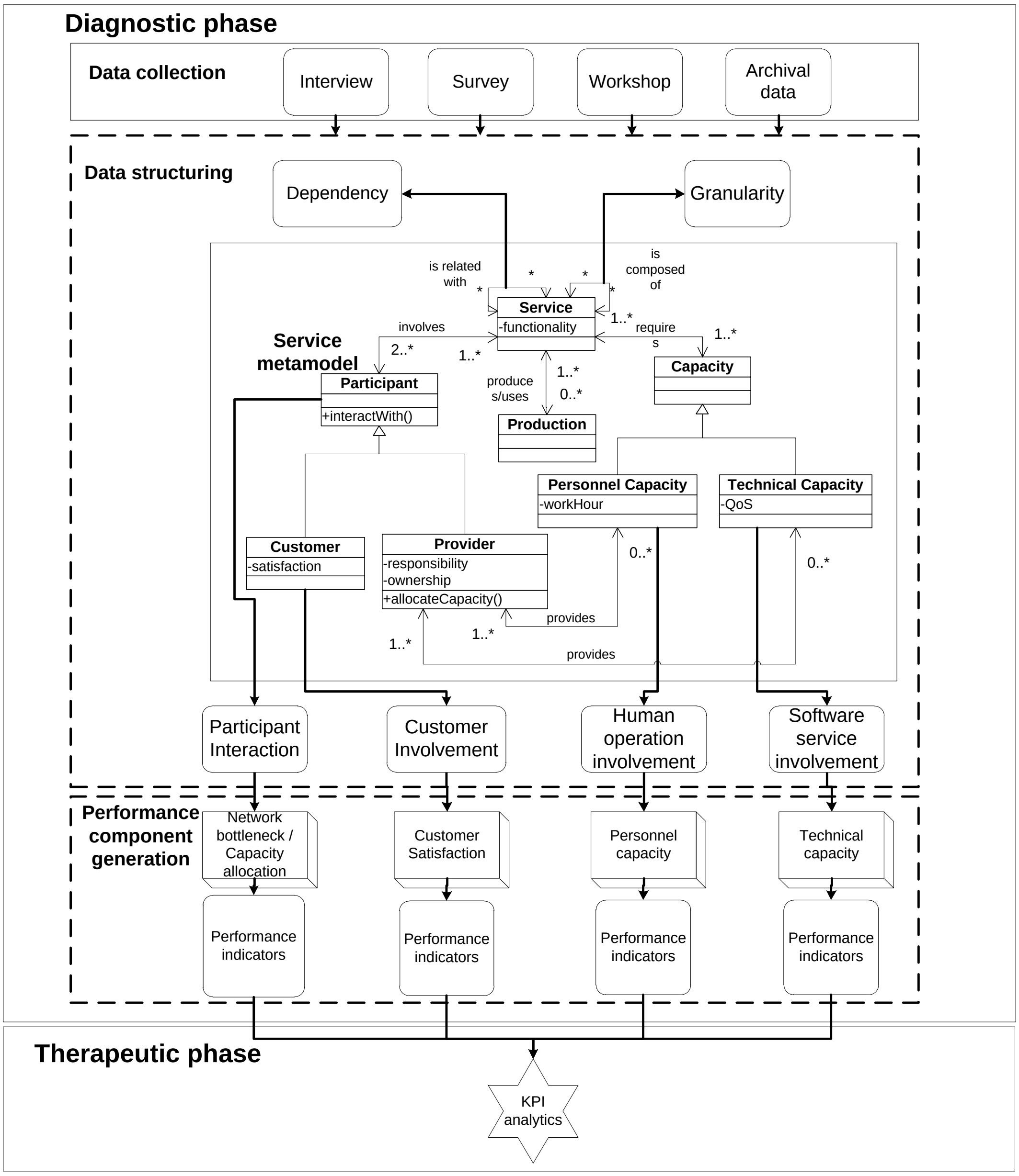
From the perspective of systems thinking, the complexity in SNs comes from the ambiguity concerning the semantic interpretations of various types of services and service resources, and the multiple interactions of the service participants. The SN's performance can only possibly be measured based on correct data collection from the living complexity. This drives us to model correct SN essential information in this section at the meta level and assess services from multiple perspectives.

Data collection

The proposed framework will be applied to complex real-world cases. In order to comprehend the reality, triangulation is used in data collection. Case data are collected from semi-structured field interviews, workshops, surveys and historical archival data. The interviews are roughly structured according to a simplified

[2] What is presented in this base solution is the initial version of this framework, which is going to be applied through three rounds of case studies for validation and improvement.

Figure 4.1: Service Network Diagnostic Framework (initial version)



version of Zachman framework [176] with focuses mainly taken from contextual, conceptual and logical perspectives. The workshops were conducted following the so-called group model-building method [177]. Face-to-face surveys are designed to get informants' opinion on specific issues. Archival data include project documentation and weekly / monthly reports.

Data structuring

Service metamodeling in SN As already mentioned in section 4.2.1, an SN's core elements are identified from those perspectives where semantic ambiguity emerges. These elements include service participants, personnel capacity, technical capacity, and service associations, while the service participants could be individuals, a group of people, organizational units or software applications.

To avoid the complexity at instance level, a metamodel with bi-dimensional considerations is generated for assessing the service essence in SNs. We identify the core network elements and the interrelations between them in a UML class diagram.

Generally speaking, one service performs a certain functionality, involves two types of participants *(customer and provider)* and requires two types of capacity *(personnel and technical)* in accomplishing the provisioning process by delivering a product. The service activity is conducted through interactions between the participants. The service provider owns the required capacity and is responsible for allocating the capacity according to the service requirements. Depending on the instance of service, the provider may provide the personnel capacity which comes from human operation, the technical capacity which relies on the quality of software services, or both. In SNs at instance level, multiple services are interconnected, therefore at metamodel level, one service is related with one or more other services in the network. One service product could be the input for another one. By product, we mean the overall outcome of a service operation, regardless of the detailed value objects during the operation. The provision of required capacity in one service could be the assumption of another service. For one specific participant, the role of customer or provider is relative. For one specific service, its functionality may be viewed with different scopes and visibilities.

Service value is considered outside the scope of this metamodel. If value is derived and determined in use [44], then it results from multiple participant interactions in consuming the network resources. Given the research objective, which is to bridge the multiple dimensions in SNs and optimize SN performance at operational level, the proposed diagnostics will focus on illustrating the essential concepts and constructs of the SN's performance, instead of measuring the value proposition among them from an economic perspective.

Service assessment criteria A set of assessment criteria from the above metamodel description can be generated and highlighted as follows:

* **Customer involvement**: who the customer is and how much the end customer is involved in the service operation. The extent of customer involvement indicates on which SN level the service operation is carried out. The higher level the service is at the network, the more the customer is involved. This criterion also helps to identify the most influential factors in customer

satisfaction, since the latter is determined directly by the service operation that a customer is involved in.

* **Participant interaction**: who are involved and how intensively the service network participants involved coordinate the service operation. The identification of service provider and customer clarifies the responsibility and ownership in a service operation. In addition, the intensity of the interaction implies potential network performance bottleneck and extra capacity allocation.

* **Human operation involvement**: the degree to which human operation is involved in executing the service operations, such as service delivery and usage. The aim of this criterion is to identify the required personnel capacity in operating the service being assessed.

* **Software service involvement**: the degree to which software application is involved in executing the service operations, such as service delivery and usage. The aim of this criterion is to identify the required technological capacity in operating the service being assessed.

* **Dependency**: the degree to which one service relies on each of the other services from a constructional point of view. Checking the (inter)dependency of a service provides us with a clear picture of its relationship with other services. Furthermore, it helps to form an overview of the service operation structure in the SNs.

* **Granularity**: the involved participants may perceive different granularities of the same service, due to the extent to which the service operation is visible to them. Any discrepancy in their interpretations of the same service arises from this differing visibility. This criterion allows participants to compare the composition level of the same service from both business and technical perspectives, so that the different perceptions held by top-down and bottom-up approaches will be revealed.

These six criteria are generated from the core network elements in the metamodel, and are interrelated in service operations. They can be used as a lens to examine and reveal a holistic picture of all the service resources consumed in SNs operations.

Performance components generation

A balanced standpoint [160], taken with both business and IT vision, views service performance from four aspects, namely customer involvement, participant interaction, human operation involvement and software service involvement.

From each aspect, a performance component is further derived which comprises both business and IT measurements of service performance:

* **Customer satisfaction** is determined by the difference between customer's expectations and perceived services [54]. During the service provisioning process, it is influenced by the perceived service performance, may include the cost, service time, product quality and the interaction with service providers.
* **Network bottleneck/capacity allocation** can be checked by examining the intensity of participant interactions. On one hand, a network bottleneck slows down the service provisioning process, where the interactions between participants may become less smooth and encounter a long response time. On the other hand, the participant interaction may become quite intensive caused by repetition of the same service operation due to the low success rate at the bottleneck. Both situations indicate that there is a need for extra capacity allocation.
* **Personnel capacity** is related to the personnel efforts dedicated and to their competence. These may be quantified by the number of working hours and the number of certified qualifications.
* **Technical capacity** is reflected in the quality attributes elicited in existing Quality of Service (QoS) metrics for software services [178] that can be adopted as measurements for illustrating the technological capacity.

These performance components represent different aspects of the SN's performance, across multiple SN layers. Each of them contains a set of performance indicators that are used to measure performance according to particular interests of the SN's managers. The correlations between the service performance and the service operations can be traced back in the way that they were derived from essential model of the SNs. After this modeling stage, the assorted SNs performance information will be well collected and categorized.

4.3.2 Therapeutic phase

The contents presented in the section is the answer to the following research question:

> **Q3.5. What analytics can be used to discover and improve operational performance issues in IT-enabled SSC?**

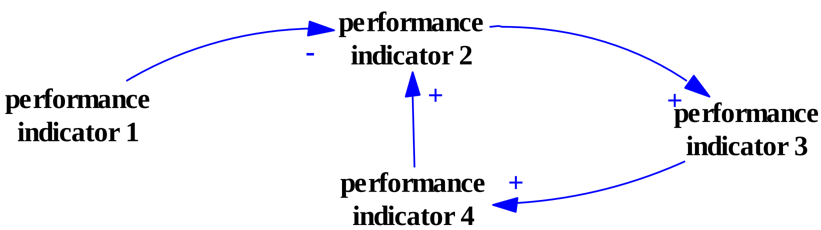
Having all the essential and classified information from the diagnostic stage, conceptual KPI analytics is performed in this therapeutic stage. Several candidate methods are available for solution finding. In this section the argument for the adoption of causal analysis of the service performance components and SD simulation will be made. Please note that in Figure 4.1, none of these specific methods is as yet inserted into this initial design. This phase is simply denoted 'KPI analytics', since it will only become clear which method will be actually needed or in what way it can help to solve the problem, after applying the framework to case studies. The application of performance analytics depends on the case context and particular problematic conditions.

Service performance causal relations

The causal relations among the service performance indicators are the connections that bridge the multiple SNs dimensions. The causal relations among the performance indicators represent the performance structure of SNs. This structure traces the effect of changes in the network and shows the services or participants that are influenced and responsible. Thus the dynamics in SNs can be revealed by the causal relations among the service performance indicators, and the ongoing business process of SNs is steered by these dynamics.

A typical causal diagram (Figure 4.2) is composed with performance indicators that are connected by the causal relations among them. Each causal relationship is labeled with polarity, either positive or negative, indicating the feedback loops between the performance indicators. The causally connected indicators may belong to different performance components, implying that these components are interrelated with each other in a network setting. Thus it bridges different SN layers in terms of the interrelationships between the performance components from each layer.

Figure 4.2: An Exemplary Causal Diagram



SN simulation

SSC performance is overwhelmingly complex, exhibiting non-linear, emergent and dynamic behavior that is notoriously hard to understand, analyze and predict. Based on the comparison results of major simulation methods in section

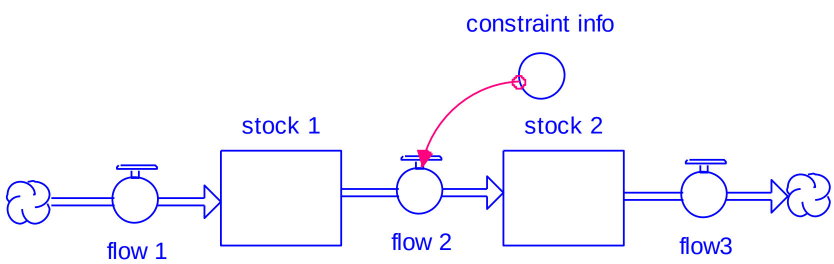
4.2.1, systems thinking is considered as the steering mindset of this research. **SD is chosen as a proper simulation technique to measure service performance in SNs**, because it focuses on causal relations among system elements and can model the continuous nonlinear process in SNs at aggregated level.

SD is a particularly useful tool to assist supply chain managers that are concerned with the impact of changes in the network on real-world operations, allowing them to explore and validate various alternative scenarios for new or improved services, reach common understanding and consensus amongst various network participants and educate them, without disrupting operational business processes.

In its basic form, SD analyzes feedback loops and the emerging behavioral effects that result from them. It models populations as discrete actors and conceptualizes processes in terms of aggregated stocks and flows and constraint information (Figure 4.3). Stocks are the accumulation of resources at different states in the processes, which can be material, people, money and so on. The flows connect the stocks and provide the channel for transporting objects from one stock to another one. The rates of movement are determined by the constraint information which comes from the behavior of other parts of the system.

The causal diagram obtained from the previous modeling step provides the performance abstractions of the SNs, where specific performance parameters can be altered in the SD simulation model for studying the performance impact over time. Depending on the situation in the specific instance, the targeting performance indicators are usually modeled as stock, while the other influential factors may be modeled as either constraint information or stocks. The polarities denoting the causal relationships are interpreted in concrete mathematical formulas for defining the value of stocks, flows and constraint information.

Figure 4.3: Stock and Flow Diagram



4.4 Design evaluation

The evaluation of the framework, according to the research design (chapter 3.1), is done via real world case studies. Three cases from the Dutch telecommunications and ICT service provider KPN were chosen. Chapter 5 - 7 present the implementation of the framework in these cases respectively. In every case study the framework applied aims to discover or solve one particular problem. Throughout each case the framework will be improved and the new version will be applied in the next case.

4.4.1 Improvement from case one

Case one focuses on the IT development in relation to KPN's mobile service operations. Having the service network diagnostic framework applied, an operational performance gap was discovered between the IT development and the service operations. This gap results from the different performance focuses of the mobile radio network operations and its IT development. Detailed case description and analysis is presented in Chapter 5.

The operational gap in this case is straightforward, which has been reported as the DevOps gap [25]. This comparably simple case serves as a good testing base for the framework and helps to familiarize readers with the context of IT-enabled SSC in general and KPN service in particular. Based on case one, the following suggestions are made to improve the framework design.

The context of IT-enabled SSC

IT development is fundamental to IT-enabled service operation. Nevertheless, human operations play an even more critical role in developing and operating IT systems. The level of service stakeholders' knowledge of technologies, project execution and, more importantly, their understanding of other stakeholders' perceptions, all have a big influence on the performance of IT-enabled SSC. Therefore, when assessing service operations, knowledge level should be added as an additional indicator in the performance component 'personnel capacity'. This is an addition to what was stipulated in relation to personnel capacity in the initial version of the framework.

Performance analytics

The first operational performance gap was discovered without building causal diagrams or an SD simulation model. On one hand, this shows that certain performance gaps can be discovered and well analyzed from effective static modeling. The framework application should have a certain level of flexibility in terms of performing recommended modeling methods and analytics.

On the other hand, these two methods - causal diagrams and SD simulation - are closely associated with concrete actions in bridging operational performance gaps. Based on the first application, these two methods will be needed in further work to bridge IT development and mobile service operation, for instance to explore the structural connection between different sets of KPIs, or to perform causality checking across IT development process and mobile service operational process.

There could be more explicit conditions regarding the application of systems thinking and of these two methods in the design of the therapeutic phase.

Gap formalism

The influential factors behind an operational performance gap could be numerous and come from various issues. They can be elicited in the static modeling phase or be discovered in dynamic performance analytics. Considering the complexity of IT-enabled SSC, it is helpful to present case conditions with a formalized description of the operational performance gap with its influential factors. The gap formalism defines the root causes of an operational performance gap and describes the factors that can be tuned for performance improvement.

With the above reflected in an updated framework, the improved design is presented in Figure 4.4. This new version will be applied in the next case study.

4.4.2 Improvement from case two

Case two focuses on how diverse operations in KPN's fixed line E2E services should be 'bridged' in the context of outsourcing. A performance gap is discovered within the operations that are carried out by different operational departments from KPN and its contracted suppliers. Detailed case description and analysis is presented in Chapter 6.

The added value of introducing the causal analysis and simulation modeling was proven on the basis of this case study. Regarding the performance gap in the service operations in the fixed-line SSC, the built causal diagrams and simulation model helped to reveal the performance linkages among all the operations involved and to test the performance impact caused by the changes of certain performance issues.

The causal analysis was conducted in a series of steps to generate the causal loops. These steps include:

- Identifying the KPI list for every service operation.
- Building causal loops within one or more focal operations.
- Extending the built causal loops by linking more KPIs from other operations.
- Creating the causal links among service operations by grouping associated KPIs.

This four-step approach provides clear, progressive instructions to explore and construct causal relationships among performance indicators. It can also be considered as a guideline on building system dynamics model from narratives. Nevertheless, there is one issue discovered during the application of this approach that may cause confusion. More explanations are given below to increase the usability of this approach in the next case study.

Additional performance indicators in causal analysis

When having the four-step approach applied to build the causal diagrams (Figure 6.5 and 6.6), there were more performance indicators structured in the causal loops, which were not found in the defined KPIs (Appendix A.4.3). Those performance indicators were generated from the case material collected by applying the proposed performance components (Table 6.5). Instead of causing confusions, the mismatch between these additional performance indicators and the defined KPIs actually facilitated the understanding of the causal relationships among the service operations. It provided a common ground to connect the defined KPIs of different service operations, and to bridge the gaps between these separately managed operations and the E2E service performance.

The construction of a causal diagram is not simply linking the performance indicators on the basis of their definitions, but is also a process of discovering the hidden connections among them. Specific attention needs to be paid to finding the common ground of those performance indicators, especially when they belong to different service operations. With the above reflected in an updated framework, the improved design is found in Figure 4.5. This new version will be applied in the next case study.

4.4.3 Improvement from case three

Case three focuses on how managerial decisions and operational performance should be 'bridged' in the context of KPN's innovation-driven iTV service. This performance gap results from insufficient insights and lack of a learning loop in managing iTV services. Detailed case description and analysis is presented in Chapter 7.

In this case study, the effectiveness of the propose service network diagnostic framework (Figure 4.5) was demonstrated in the context of service operations management. In the diagnostic phase, the structured modeling steps, namely data collection, data structuring, and performance component generation, led a smooth modeling approach to access intensive case material.

The properly structured performance information was further analyzed in the therapeutic phase. The four-step causal analysis approach provided a good transition from descriptive data analysis into constructive modeling process. Differing from its application in the previous case study, the four-step approach was implemented in a more flexible way. Because of specific case situations, certain steps in the proposed approach could be combined or repeated. For instance in this case study, contents in step three 'causal connections among iTV services' came from applying step two and three in the approach, and the contents in step four 'managerial tradeoffs' resulted from repeating these two steps. Since these results were well received in this case study, such flexibility in applying this four-step approach was appreciated and should be indicated in the proposed framework.

The bridging efforts towards operational performance alignment were built through a solution searching process, including simulation modeling and performance analytics. In this case, the system dynamics simulation created an environment for evaluating different service policies. The simulation results provided a collective consequences of scenarios on performance issues across different service operations. Having the simulation results at hand, the performance analytics generated the pros and cons of each service policy and indicated the operational priorities.

With the above evaluation reflected in an updated framework, the final version of the service network diagnostic framework is found in Figure 4.6.

4.5 Conclusion

This chapter has illustrated the development of the service network diagnostic framework, which corresponds to the solution design phase and design evaluation phase of this thesis (Figure 1.5). The proposed framework is a communication-centered method and combines both business and technical perspectives to assess services in SN. It provides modeling steps for users to collect, structure, generalize and analyze performance information of complex SSCs.

Design goals revisited

Clarity of terminology

In the framework designed in this chapter, clear definitions and explanations are provided to all network elements and performance components. Only the core elements are modeled and only the key performance criteria are used to assess the performance of IT-enabled SSC. Modeling at the meta level allows every term used stay at a broader scope, which avoids confusions caused at instance level.

However there is still a concern in the terminology used in developing this framework. The words, service network and service supply chain, are used interchangeably in this chapter and in other parts of this thesis. On the one hand this indeed causes confusion for readers, especially people with either a supply chain management background or an information systems background. On the other hand, this proves exactly the paucity of this type of research, hence the bridge of dreams. Within the perspective adopted by this research, both terms are equivalent when referring to the complex environment of providing IT-enabled services.

State-of-the-art SSC modeling and simulation

The modeling and simulation approaches adopted in the framework are chosen and structured on the basis of reviewing several existing SSC modeling and simulation methods. Considering different level of abstraction and focuses in those methods, the framework chooses to conduct modeling at two stages. The diagnostic phase includes static modeling approaches, while the therapeutic phase includes dynamic modeling approaches.

The meta model designed in the static modeling stage holds a holistic scope (Figure 2.2) and integrates all key service elements (Table 4.2) from both business and technical perspectives. The simulation approach in the dynamic modeling state is chosen by comparing features of several mainstream simulation techniques (Table 4.3) with the characteristics of SN and the objective of this research.

Best-of-breed framework composition

The framework is flexible to incorporate new methods and approaches on the basis of case conditions. In the current final version of the framework (Figure 4.6), all analytics in the therapeutic phase were added from different case studies and are kept optional. Depending on case conditions, it is still possible to adopt other methods for specific performance analysis. The gap formalism reflects the structure of operational performance in different case conditions, which offers a clean overview of performance factors and could be easily adjusted and tuned for performance improvement.

Limitations

Despite having the above comprehensive design objectives fulfilled, the framework is still presented with a high level of abstraction. The author prefers to keep the framework in a simple form, as it functions mainly as a 'bridge' between various existing modeling and analytical methods. Thus the design activities focus on validating the structure of this framework, rather than specifying the details of each modeling an analytical method involved. Nonetheless, it is a reasonable recommendation to further specify and customize modeling guidelines when using them in different case settings or environment.

Another issue that might receive questions is how to approach saturation in the framework design. For the purpose of this research, the framework improvements made from three case studies can be considered sufficient evidence on this issue. In the first case it discovered the DevOps gap, which has been known from previous research and provides confirmation on the feasibility of the framework design. In the second and third case, the framework was further applied to different tiers of IT-enabled SSC, and the gaps discovered and issued tackled were confirmed by key case informants. The complexity of the cases chosen for the framework application evolves, which proves that the applicability and validity of the framework in different case conditions.

Figure 4.4: Improved Version of the Service Network Diagnostic Framework after Case One

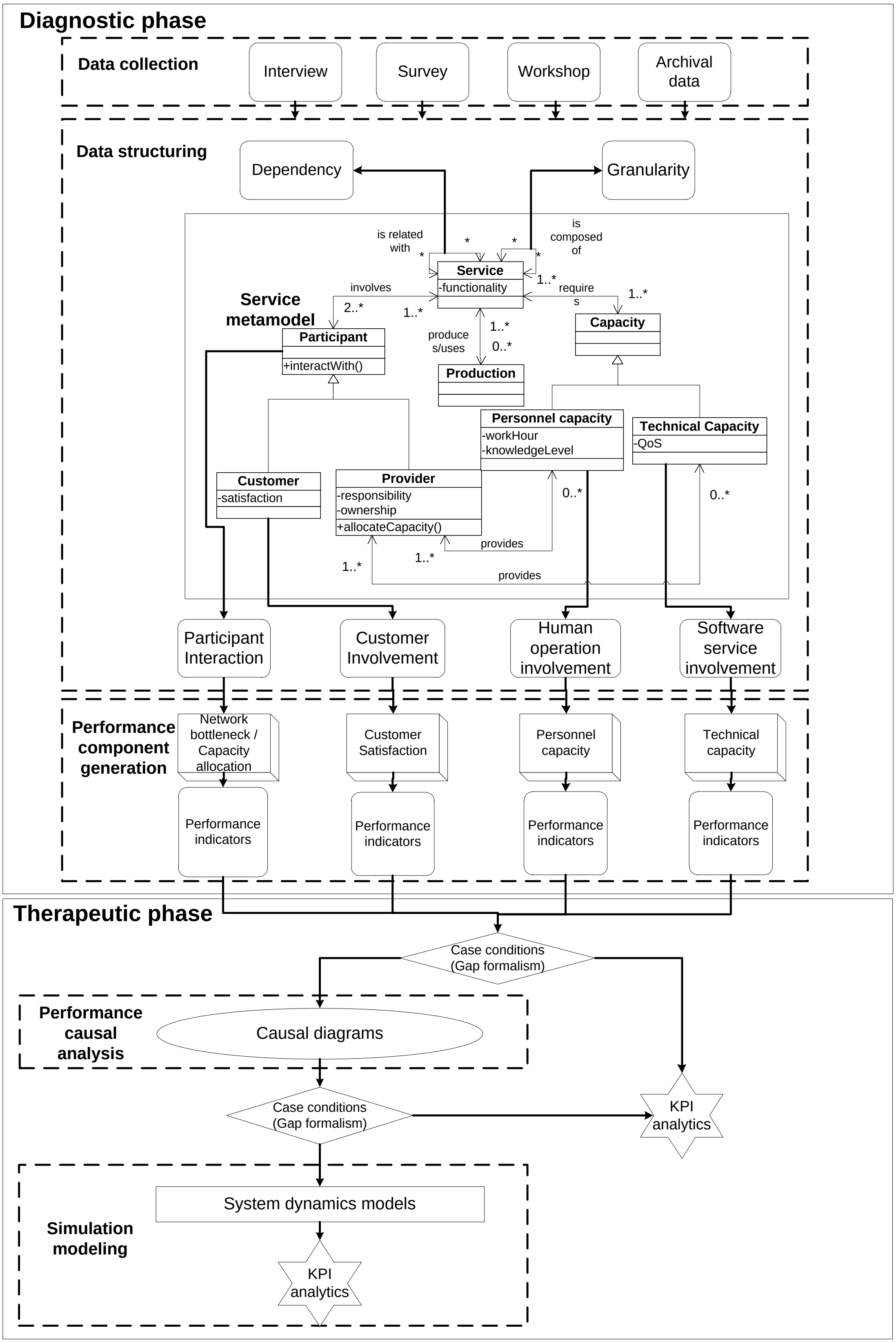


Figure 4.5: Improved Version of the Service Network Diagnostic Framework after Case Two

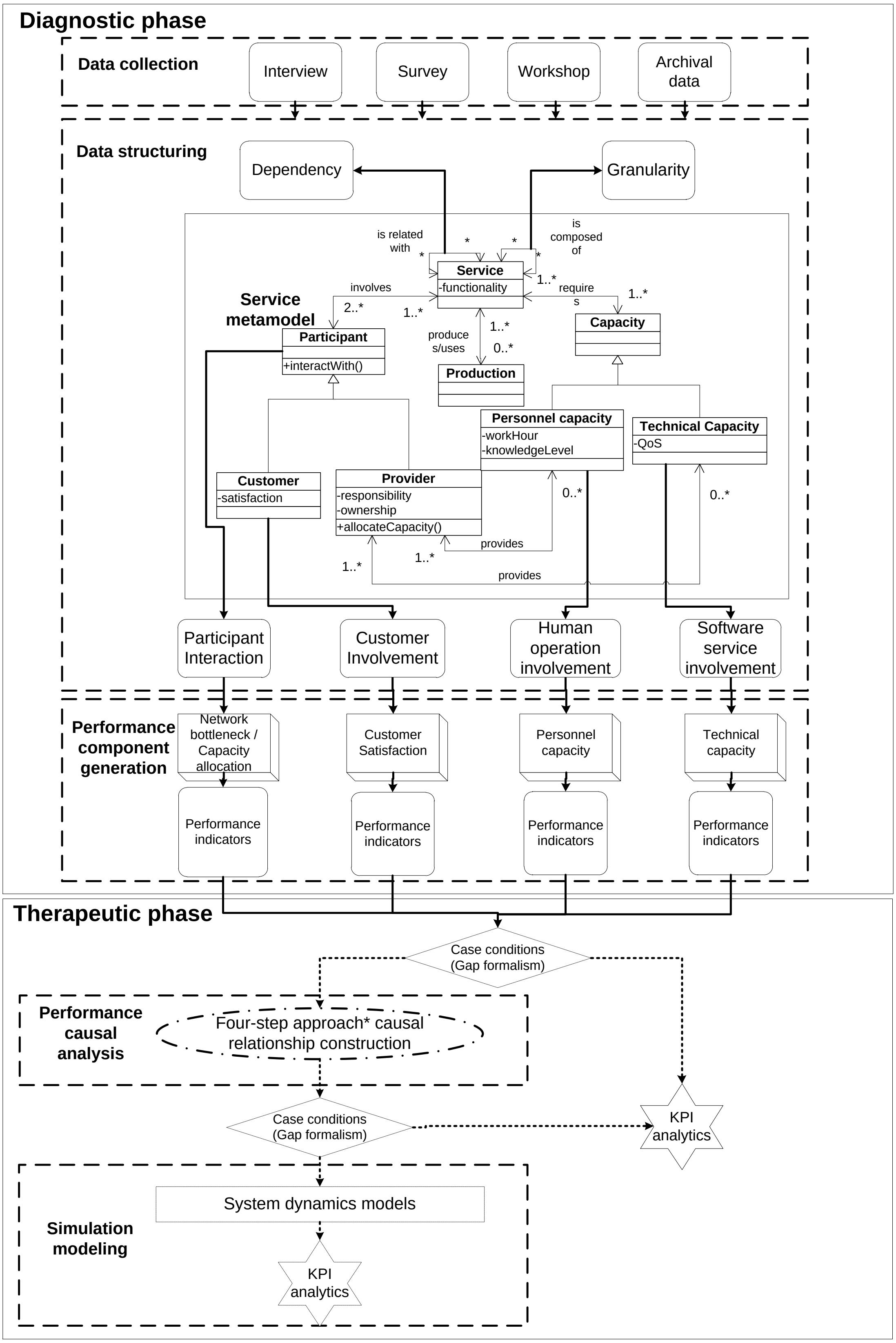
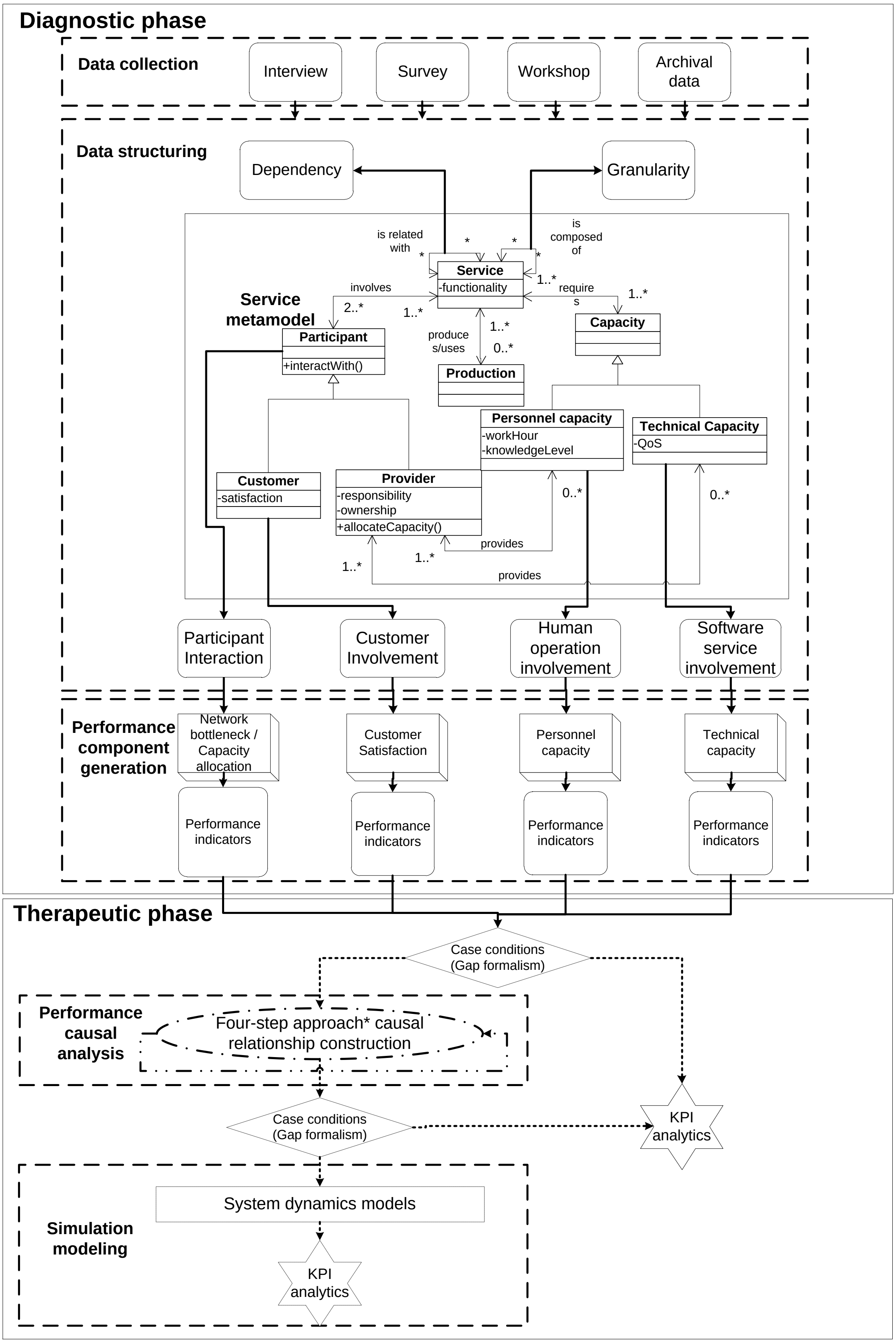


Figure 4.6: Final Version of the Service Network Diagnostic Framework



CHAPTER 5

CASE ONE: IT DELIVERY IN MOBILE SERVICE OPERATIONS

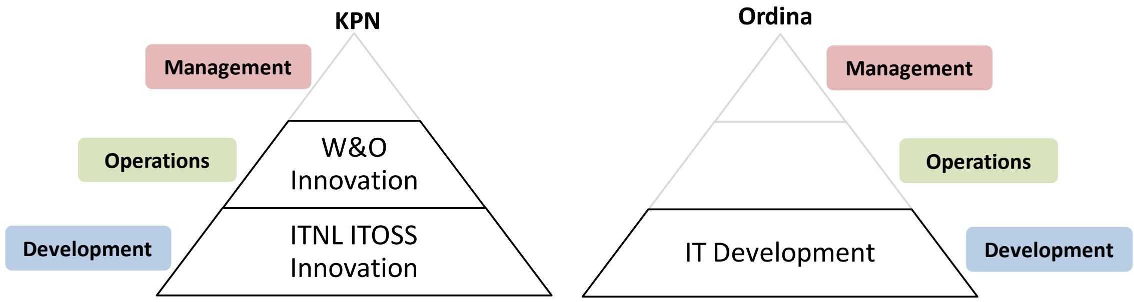
KPN is a Dutch leading telecommunications and ICT service company, offering wireline and wireless telephony, internet and TV to consumers, and end-to-end telecommunications and ICT services to business customers. Three cases from different services provided by KPN Nederland are selected by this research to validate the framework (Chapter 4) designed for aligning IT-enabled SSC operational performance.

The contents presented in this chapter aims to answer the following research questions:

> **Q4.1. Can the IT-enabled SSC studied be comprehensively and accurately modeled?**
>
> **Q4.2. Can the operational performance issues in the IT-enabled SSC studied be successfully discovered and analyzed?**
>
> **Q4.3. Can the chosen analytics improve the operational performance issues discovered?**

The challenge of Business-IT alignment (BIA) still dominates concerns about business performance. One of the alignment levels for Business and IT is set at the operational level. This provides a good standpoint for this research which focuses on DevOps performance alignment. The first case study is about IT delivery in KPN's mobile services,[1] located within KPN ITNL and W&O, as well as with the contracted software supplier Ordina. The scope of the case study covers the following stages (Figure 5.1). Business requirements from service operations in W&O Innovation are transformed into technical requirements for IT development in ITNL ITOSS Innovation. Then, the technical requirements are forwarded to Ordina for the building of actual IT application. Because of the crossover between operations and development, this is an appropriate starting point for the exploration of business-IT gaps at DevOps level in innovation-driven service organizations.

Figure 5.1: The Scope of Case One



The rest of this chapter is organized according to the proposed service network diagnostic framework (Figure 4.1) in chapter 4. The case study is presented in two phases, namely the diagnostic phase and the therapeutic phase. In the diagnostic phase (section 5.1), the study starts with data collection (section 5.1.1), where a general synopsis of the innovation project in mobile services is created. The large amount of case material is structured (section 5.1.2) by applying the metamodel and performance assessment criteria proposed in the framework. Furthermore, information on the key aspects of performance is generated, based on the identification of service supply chain performance components (section 5.1.3). When all the information is properly classified and filtered, the therapeutic phase (section 5.2) begins. The performance issues are discovered (section 5.2.1) and analyzed (section 5.2.2) using systems thinking, and the first type of performance gap is revealed. This case study is concluded with the performance gap identified and bridging attempts proposed (section 5.3).

[1] KPN's organizational structure can be found in Appendix A.2.1. The background and setting of KPN's mobile service can be found in the Appendix A.2.3.

5.1 Diagnostic phase

Despite the overall research focus being the issue of business-IT alignment, specific problems need to be identified in each case study. This is only possibly if correct data collection is extracted from the complexities of the situation, assembled and processed.

5.1.1 Data collection

The first case study is about IT delivery in KPN's mobile services. It is difficult to create a focus on the research topic, when the problem is either not obvious to the development team or is not their major concern or responsibility. In order to become familiar with the situation, various data collection methods were used. The case material was collected from 22 semi-structured interviews with informants from 10 different departments / organizations (see Appendix A.3.1, Table A.1), as well as release documents and reports from this mobile innovation project.

After collecting in-depth data on mobile service innovation from a broad range of respondents, without any further data analysis and overview of the innovation project was already possible. The case synopsis is presented here.

Case synopsis

In order to handle the huge demand from a growing customer base, KPN launched a series of company-wide innovation programs in 2011. In the area of mobile service, one of the programs was to implement a new radio network controller that aimed to supplement the current radio network controller and expand the volume of transmission that could be handled in the 2G / 3G network. This network change required corresponding changes in the functions and settings in network configuration. One major task in this innovation program was to design and develop new functionality and settings for two main IT systems, namely the registration system, Prime, and the radio control system, Radion. In this case study, the focus was on **the innovation project that was mainly concerned about the IT development process**.

Every innovation program contained several projects. In each innovation project, the new product was delivered through a series of releases, which captured and deliverd business value incrementally. Essential Unified Process (EssUP) [102] was widely adopted by KPN ITNL in cooperating with business stakeholders for internal delivery. Each release contained four types of iteration phase, namely the inception phase, elaboration phase, the construction phase and the transition phase. Each iteration phase was scheduled to have a fixed time window of four weeks. If the first phase of certain type could not accomplish its defined objectives, a second iteration phase of the same type was scheduled. At the end of each iteration phase, stakeholders came together in an assessment meeting where they made a joint decisions on whether it was a 'go' or a 'no go'. The releases within a project were scheduled periodically. One release would start when the previous one has completed its elaboration phase. This implied that the first iteration phase, viz. the inception phase, of a new release started eight weeks after the beginning of the inception phase of the previous release.

Four main stakeholders were involved in the development process of the mobile innovation project under study, viz. KPN W&O innovation department as the business owner, KPN ITNL ITOSS innovation department as the project manager, Ordina as the contracted IT supplier and tester, and KPN Technical Testing & Release Center (TTRC) who also jointly performed the application testings.

5.1.2 Data structuring

The essential information on the innovation project and IT development process under research then needs to be further elicited and structured. In the proposed framework (Figure 4.1), data structuring starts with service modeling and performance assessment (more details in chapter 4.3.1). The service metamodel contains core service elements (service, customer, provider, production, technical capacity and personnel capacity) and the inter-relation among them. By applying the metamodel, two types of services and processes are discovered from this case, viz. the mobile service and network operational process, and the innovation project and IT development process.

A set of service assessment criteria is generated based on the service metamodel. These criteria include customer involvement, participant interaction, the involvement of human operation, software service involvement, dependency and granularity. **Given the focus and the information available in this case, the performance assessment was carried out on the innovation project alone**.

Modeling of mobile service and the network operational process

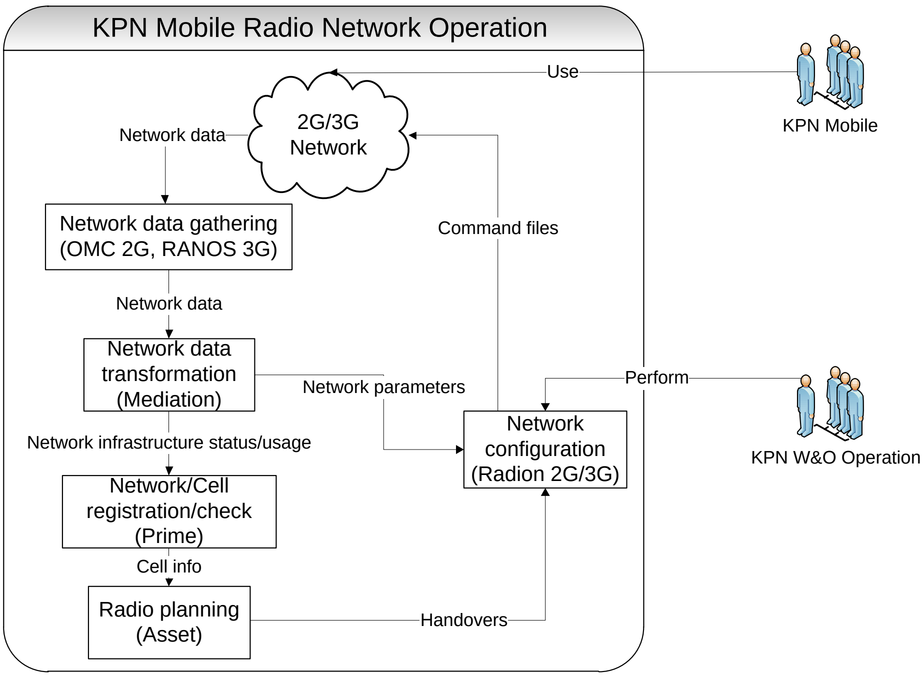
For KPN, operating the mobile radio network is one of their core business services. The key user of the mobile service is KPN Mobile, while the provider of this business service is the mobile network operator, namely KPN W&O Operation. In order to offer and maintain this service, daily optimization of mobile radio network configuration is the main product delivered by KPN W&O Operation. It requires the technical environment of the mobile radio network, as well as personnel and knowledge from the service provider. Table 5.1 summarizes the essential information of the KPN mobile service.

Table 5.1: Essential Information on KPN Mobile Service

Core elements	Descriptions
Service	Mobile radio network operation
Customer	KPM Mobile
Provider	KPN W&O Operation
Production	Daily optimization of network configuration
Technical capacity	Mobile radio network
Personnel capacity	Personnel and knowledge level from provider KPN W&O Operation

The operational process of the mobile radio network is shown in Figure 5.2. More detailed information can be found in Appendix A.2.3.

Figure 5.2: Mobile Radio Network Operations



Modeling of the innovation project and the IT development process

Throughout the whole KPN supply chain, the innovation project was the single service that delivered new IT applications for mobile network operations. This service was offered jointly by KPN ITNL ITOSS Innovation, Ordina and KPN W&O TTRC. The service was provided at the request of KPN W&O Innovation, who acted as the customer. The project was divided into two parts for the innovation of two IT systems, viz. Prime and Radion respectively. **This case study focused only on the innovation of Radion**. Therefore the major product of the innovation project under research was the implementation of the changed IT functionality of Radion. The required technical capacity was the development and testing environments for Radion. The required personnel capacity was the personnel and knowledge from both customer and providers. Table 5.2 summarizes this information.

Table 5.2: Essential Information on the Innovation Project

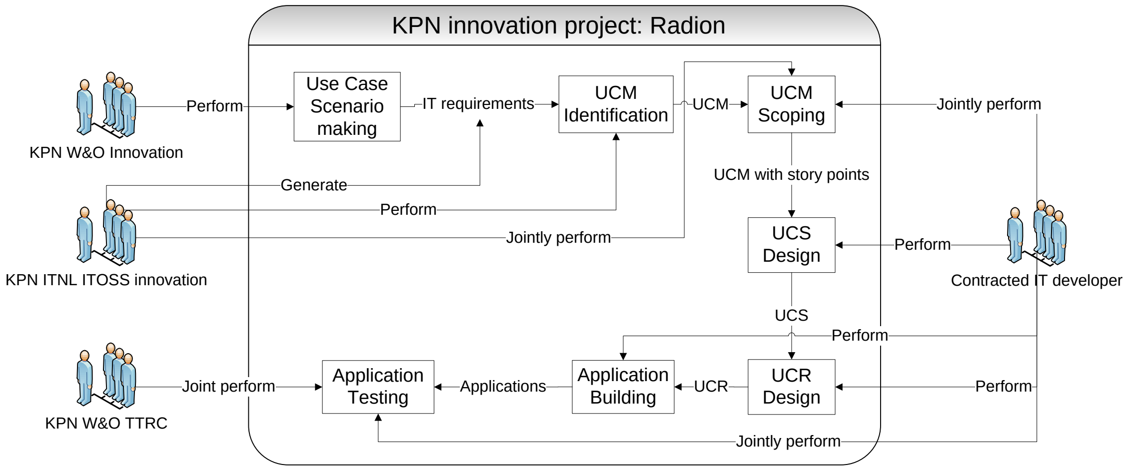
Core elements	**Descriptions**
Service	development of new functionality and settings in mobile network operation
Customer	KPN W&O Innovation
Provider	KPN ITNL ITOSS Innovation, Ordina, KPN W&O TTRC
Production	The implementation of the changed IT functionality of Radion
Technical capacity	Development and testing environments for Radion
Personnel capacity	Personnel and knowledge level of both customer and provider

The operational process in this innovation project was the delivery process of required IT applications, which was in terms of a series of IT development activities. The same core elements were applied in specifying this development process by reducing the scope of each activity and identifying the providers and customers involved.

The development process (Figure 5.3) started with an IT consultant from ITNL ITOSS innovation turning the business requirements from TI network designer in W&O innovation into a set of use case modules (UCM). The IT consultant might need to contact the key user (KPN mobile) and TI network designer for calrification on particular requirement during the requirement engineering process. An official document containing the outline of the identified UCM was sent from the KPN ITNL IT consultant to the IT designers at Ordina who further specified the functional description of every UCM into use case specification (UCS) documents. Then the UCS documents were handed over to the IT developers inside Ordina for detailed system-level use case realization (UCR) design. The UCR documents was used in building the software applications.

During the process of UCS design, the IT designer might consult the IT consultant from KPN ITNL ITOSS innovation, or might directly contact either the key user from KPN Mobile or the TI network designer from KPN W&O innovation for additional information. In the latter case, the IT consultant was not aware of the communication between Ordina and key user / TI network designer, nor the information exchanged. Once the UCR documents were created, there was an official review process performed within Ordina that focused on consistency between UCS and UCR documents. The testing activities for the IT applications were carried out jointly by Ordina and KPN TRCC.

Figure 5.3: The development Process of KPN innovation project



Performance assessment of the innovation project

Having the core elements and process of the innovation project structured, its performance was further assessed. The framework provides six criteria for assessing service performance. Table 5.3 highlights the innovation project performance from these six aspects.

Table 5.3: Performance Assessment of the Innovation Project

Assessment Criteria	**Descriptions**
Customer involvement	KPN W&O Innovation was directly involved in specifying business requirements and reviewing the design, but not familiar with the process by which the requirements were transformed into technical design and realization.
Participant interaction	KPN ITNL ITOSS Innovation had intensive communication with KPN W&O Innovation and Ordina, respectively, on a daily basis. Occasionally there were also information exchanges between KPN W&O Innovation. At the end of each release iteration phase, there was a joint assessment meeting with all participants.
Human operation involvement	Personnel capacity (employee workload) was strongly required from all participants in requirements generation and transformations. In addition, participants' knowledge of technologies, project execution and understanding of the perception of others in the project was influential in the IT development as well as network operations.
Software service involvement	Technical capacity, in terms of the development and testing environment of Radion, was needed mainly in application building and testing.
Granularity	Seen from operational process level: low, the innovation project was for producing IT systems for network operations. Seen at development process level: high, the innovation project was composed of use case scenario making, UCM identification, UCM scoping, UCS design, UCR design, application building and application testing.
Dependency	The innovation project relied on the accomplishment of use case scenario making, UCM identification, UCM scoping, UCS design, UCR design, application building and application testing.

5.1.3 Performance component generation

The operational performance of the innovation project depended on how well the IT development process performed. This implies that the indicators of the overall project performance were associated with different aspects of the IT development process. According to the proposed framework, these indicators were grouped into four types of performance components, namely customer satisfaction, network bottleneck / capacity allocation, personnel capacity, and technical capacity. Applying these components to the IT development process, clear measurements of the performance of the innovation project can be obtained. Table 5.4 lists these performance indicators according to corresponding categories.

For the customer, KPN W&O Innovation, it was important that the products were delivered on time and were of good quality. From the project management perspective, the customer was satisfied when there was less risk in the innovation project; when there were more tested products being delivered; when there were more objectives achieved; when there were fewer errors detected in products testing.

From the process management perspective, the interactions among participants involved had great influence on process performance. Process bottleneck might be a potential capacity trap. In the IT development process, the potential for bottlenecks was measured by the density of information exchange between participants, and the available supporting documentations. If the information exchange was very intensive in relation to a certain process step or activity, it implied that this was either a critical operation or there was a lack of available information or resource.

The capacity of a project directly determines the progress of the project and the outcome quality. Personnel capacity was measured by the available FTE allocated on the project, as well as the knowledge level of the FTE. Technical capacity referred to the availability of the building and testing environment for IT applications.

Table 5.4: Performance Components of the Innovation Project

Performance Components	**Performance Indicators**
Customer Satisfaction	- number of mitigated risks - number of produced/tested products - number of achieved objectives - number of detected errors in testing
Network bottleneck / capacity allocation	- number of information exchanges - available supporting documentations
Personnel Capacity	- available FTE - knowledge level
Technical Capacity	- availability of development/testing environment

Generating these performance components with concrete indicators helps to check whether the right KPIs are checked in a project dashboard. It also helps to build up a performance structure which links different aspects of project performance with operational indicators.

5.2 Therapeutic phase

Having all essential information generated from raw case material in the previous diagnostic phase, the alignment between IT development in the innovation project and mobile service operation was analyzed in the therapeutic phase. In this section, the performance issues discovered (section 5.2.1) will be introduced first, then detailed analysis of those issues will be provided (section 5.2.2).

As mentioned in the framework (chapter 4.3.2), although causal diagram and SD simulation are recommended as available tools in this phase, the actual applied analytics depends on case context and concrete requirements. In this case, a hidden problem already became clear after generating the processes and performance components of the mobile service operation and IT development. A supply chain performance gap was discovered and properly analyzed between the business (mobile service operation) and IT (IT development). Therefore causal diagram and SD simulation were not used in this case.

5.2.1 Performance issues

The problem found in the case presented was with the IT performance in mobile radio network operations. This was due to the two different processes operated by different stakeholders with completely different technical backgrounds and performance measurements. The performance of the IT systems was determined by the quality of IT development, and could only be actually measured after being applied in the operational process of the mobile radio network. The development methodology applied in IT development, EssUP, focused on functional on-time delivery during the development process. Within the scope of the IT development, there were no causality checks on the performance impact of IT systems in the mobile radio network operations.

The research focus was the innovation project. With the generation of essential supply chain information in the diagnostic phase, some performance issues encountered by stakeholders immediately came to light.

Reconciling different technical backgrounds

The stakeholders involved in the development process had different technical backgrounds and ways of working, and not all of them were fully convinced of the design methodology adopted. The methodology had been applied within ITNL where the experts had a common backgrounds. In the innovation programs, the same methodology was used as the method of achieving cooperation with business stakeholders, but n this case the business stakeholder was W&O innovation, for whom the methodology was new. In addition, W&O innovation focused on the technical requirements of the telecom technical network, while the requirement management in the innovation programs focused mainly on business requirement of the consumer market and business market. In addition, they were not used to carrying out telecom network innovation in an iterative way.

Documentation management

The software design documents were the main artifacts designed and used during the development process of the innovation project, and they were made by different stakeholders. As the joint effort of various experts, the documents were extremely complex and lacked of traceability. The TI network designer from KPN W&O innovation offered a review of the UCS and UCR documents in each release, in order to find any missing part of the design during the development process. However, because of their different background, the TI network designer could only recognize telecom parameters in the software-orientated UCR documents. Historically,there had been no technical documentation produced for the Prime and Radion systems before they were built. Ordina developers were creating the technical documentation for the existing systems while undertaking new development at the same time. But, in practice, this technical documentation was not used by KPN ITNL ITOSS innovation, due to its high content of IT-related technical details.

During the life cycle of the development process (Figure 5.3), the initial business requirements were required to go through a long communication chain crossing three different departments. According to the TI network designer, information loss was also a concern. There was intensive daily communication at release level but it was informal. Not all the information that was exchange was known to all the stakeholders involved. There was a lack of a documenting system or mechanism to support the communication in the development process.

Blind spot in the agile development process

The innovation project was managed in an agile way, by which, in general, the business value delivery was guaranteed and new requirements could be added timeously. However, the pressure for on-time delivery could be felt from the fast-paced and strictly planned development process. The quality criteria used in each iteration assessment for deciding the release progress were mainly concerned about functional requirements with limited scope, such as the number of mitigated risks, the number of produced / tested products and the number of objective achieved within one iteration phase. Despite the dynamic and responsive release planning, once a planned UCM could not be finished within one release and did not have big impact on overall function of the release product, it was left to the next release. There was an occasion when one UCM stayed in the plans of several releases and was left unfinished. Given the scope of the release progress meeting, the impact of the unfinished UCM on the overall project progress was not checked, nor its functional impact on the network configuration operation.

5.2.2 Performance analysis

Regarding the performance issues mentioned above, the analysis began with a holistic examination of the innovation project. Managing such innovation project was very complex considering the way of IT development was conducted and how IT performance was measured. The following analysis was made from these two perspectives, viz. the effectiveness of the development methodology in the innovation project, and the analysis of IT performance in mobile service operation.

Development methodology in innovation project

The Essential Unified Process (EssUP) [102] was chosen as the development methodology in the innovation project. The scope of this methodology was the release-based development process (Figure 5.3), from the generation of TI requirements for network configuration up to the implementation of tested applications.

From the information obtained from project member interviews, the adopted EssUP was proven to work well with respect to fulfilling functional requirements in the release-cased development process. According to EssUP, the functionality of required IT applications was carefully managed within a strictly planned time frame and with personnel capacity provided. A weekly progress meeting was held at release level and the product quality was checked at the end of each iteration phase by measuring the functional achievements. Nevertheless, this approach focused on the hard aspect of the release development process, such as the scoped functional design and on-time delivery. Some soft issues, for instance the completeness of the application development, were left out of consideration.

The innovation project benefited from the agility of EssUP. For instance, there were intensive interactions among participants; the project team could carry out dynamic and responsive planning in response to changes; the delivery time was predictable due to strict capacity allocation. Nevertheless, there was also information collected from interviewees which argued against these attributes of agility. Table 5.5 summarizes the comparison of the agility in the EssUP methodology and what was observed in practice.

- The intensive communication was informal and without documentation. This made information exchanges lack transparency and traceability, and not all of the stakeholders involved knew about the exchanges. This left the innovation project at risk of information loss during the development and reviewing process.
- The incremental business value delivery brought flexibility to the release development process by making planning for change dynamic. The separation of tasks saved time in the preparation of weighty documentation and building applications. However, it also made it difficult to have an overview of the development status of the innovation project, since there was insufficient baseline documentations to obtain the holistic picture.
- The predictability in time and capacity allocation was one of the advantages of the agile methodology. Although it guaranteed the efficiency of resource planning, including workload planning and solution selection, it brought up the question of whether the on-time delivery was the best delivery. According to some interviewees, because of the fast-paced development process, solution design was carried out within a short time frame by just fulfilling the bottom line needs. There was no time to assess alternative solutions which might have worked more effectively.

The effectiveness of EssUP methodology depended largely on the scope of its application domain. Within the scope of the innovation project, EssUP provided a very neat schedule for the continuous release development. This motivated all involved stakeholders to work at a steady, fast paced in the development process, and guaranteed the functional delivery of the required IT products. Nonetheless, such a development process did not facilitate traceable and transparent information exchanges. Furthermore, the quality of decision making and product control was not part of the scope of this methodology. There was no methodological sup-

Table 5.5: The comparison of agility in EssUP methodology and in practice

	Agility Attribute	Hidden Problem in Practice
1	Intensive interactions via informal communication	Lack of information transparency, traceability, and sharing
2	Light-weight documentation in dynamic planning (flexible and responsive to changes)	Insufficient baseline documents
3	Predictable time & capacity allocation	Lack of confidence in effectiveness of resource planning

port for choosing the best product solution according to demands. It also did not take into consideration any causality checks on product quality across successive releases, and this may have led to an increased risk of having quality flaws in the final product performance.

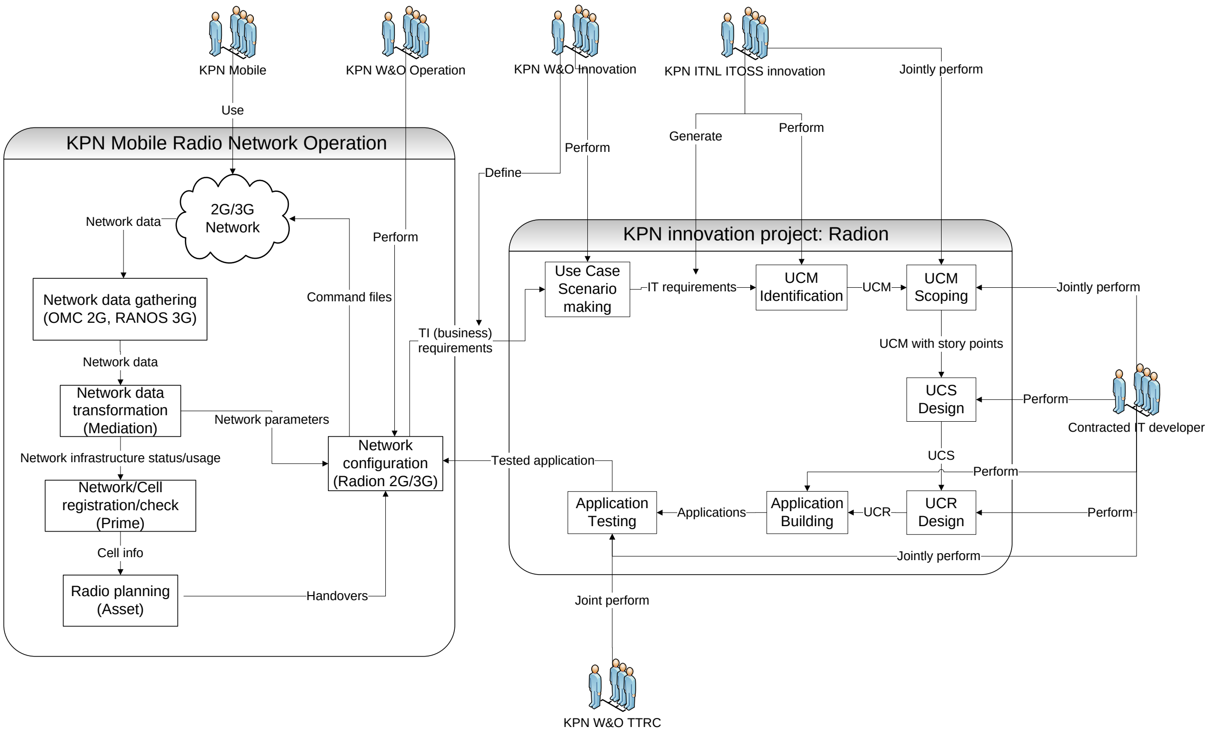
Therefore, more attention should be paid to those aspects not covered in this development methodology, particularly to the performance measurement of IT products.

IT performance analysis

In this case, the IT performance referred to the quality of IT systems produced from the innovation project. More specifically, it was the performance of the radio control system Radion, in both testing phase and implementation phase. Radion is the configuration tool used in network operations. Based on analysis in the previous diagnostic phase, the testing phase and implementation phase of Radion were managed separately in the development process (Figure 5.3) and in the mobile radio network operation process (Figure 5.2).

Figure 5.4 depicts the mobile service operation supply chain by integrating the development process and the operational process of mobile radio network operation with all stakeholders involved. The process of network operations (the left half of Figure 5.4) included operations such as Network data gathering, Network data transformation, Network/Cell registration/check, Radio planning and, the most important one, Network configuration. The innovation project carried out the IT development process. The standard development process (the right half of Figure 5.4) contained services such as Use Case Scenario making, UCM identification, UCM scoping, UCS design, UCR design, Application building and Application testing. The requirements of IT applications were based on the performance of network operations. The configuration data, as the output of network operations, was the input for IT applications.

Figure 5.4: The Mobile Service Operation Supply Chain



The mobile radio network operated entirly in IT systems, thus network performance evidently relied on the performance of IT systems in network operations. This implied that the actual performance of IT systems could only be measured in the operational process of mobile radio network operation. Measuring the actual performance of IT systems was beyond the scope of its development process in the innovation project.

Key Performance Indicators (KPIs) used in assessing the innovation project and the performance of IT systems in network operations were different.

- The specification of the IT system's performance in network operations had been defined some time previously. Existing KPIs could include: drop rate, accessibility, data throughput, voice quality, the time duration of certain import etc. These KPIs were pre-defined, and centered on customer experience of the mobile data service and other mobile radio network services. Another set of KPIs for IT systems in network operations can be found in the VITO ticketing system, and this included, for instance, the number of errors and problems detected in the testing phase and the reported problems that were encountered during the implementation of IT applications.

- On the other hand, the KPIs used in the innovation project, more specifically in the release-based development process, were taken from a project management perspective, and included the number of mitigated risks, the number of products produced or tested and the number of objectives achieved (Table 5.4).

All the above analysis led to the uncovering of the business-IT gap, in this case from a process perspective. The business (mobile radio network operation) and the IT (IT system development) had completely different focuses, processes and performance measurements. The network operational process and IT development process were and could only be managed separately, due to their scale and technological complexities. It was difficult to find connections between the KPIs used in these two processes. The link that bridged network operations and IT development was requirement engineering in the innovation project. However this bridge was a long process across the testing and implementation phase and neither the network operations nor IT development could expand their scope of responsibilities across the performance gap between them.

Considering the scope of the innovation project, the applied methodology EssUP was not sufficient for managing the performance gaps. More causality checks and formal documentation was needed as ways to 1) improve the traceability and transparency of information exchanges in the release-based IT development process, 2) reveal the causal relations across successive releases, 3)reveal the causal connection between network operations and IT development in relation to IT performance.

5.3 Summary

The outcome of this case study leads to the identification of an operational performance gap in the KPN mobile service supply chain, and suggests bridging attempts on closing the gap. This section summarizes the answers to the research questions raised at the beginning of this chapter.

5.3.1 The DevOps gap

This case study focuses on the IT development in KPN's mobile service operation. The DevOps gap results from the different performance focuses of mobile radio network operations and IT development and is located between the operational process and the development process within KPN (Figure 5.5). There has been no performance gap clearly observed between KPN and the contracted IT developer. The organizational boundaries between them were not visible in the development process because of the agile methodology applied.

The DevOps gap is not new in IT development [179], and several solutions have been proposed to close this gap and ensure continuous delivery [25] [24] [180]. Seamless communication and close cooperation have been recommended to close the DevOps gap. However it is hard to achieve in this case condition due to its the large scale and technological complexities.

Despite having mutual goals and a willingness to collaborate, the different background and visions behind the KPN mobile service operation and IT development required additional communication mechanisms and scoping in their own processes. While the flexible and effective informal daily communication between individuals should be encouraged for efficiency reasons, it also needed to be better regulated and documented. This was especially necessary when there was a long communication chain and not every individual involved was aware of all the information exchanges.

The agile development methodology adopted in IT development was good for on-time delivery, but had limited scope and mechanisms for checking the impact of release completeness on the overall project progress. Furthermore it did not provide any method for assessing the actual performance of the IT systems delivered in the mobile service operations.

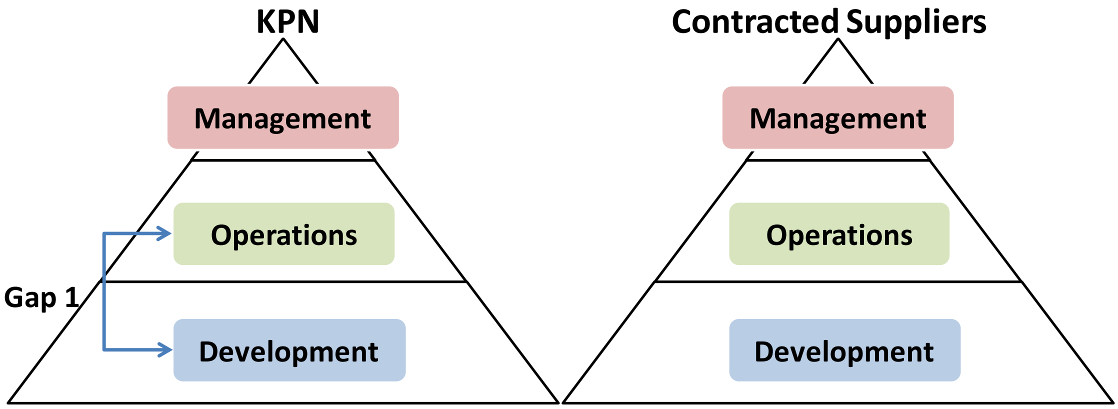
The KPIs used in the mobile service operation were different from those used in the IT development and this revealed the hidden problem in the IT development process. That process only focused on the incremental release development and failed to scope the innovation project overall, as well as the performance of the IT systems delivered in the mobile service operations. The innovation project performance was measured from a project management perspective, and did not include sufficient causality checking about the impact of the quality and progress of IT development on the performance of mobile service operations.

The discovery of the DevOps gap is made possible on the basis of comprehensive and accurate case study and modeling. Research questions 4.1. is answered by the identification of this gap.

5.3.2 Gap formalism

Having the explanation made above, the DevOps gap is determined by the length of the communication chain (denoted by L) and the quality of causality checks (denoted by Q) across the IT development process and the IT-enabled service

Figure 5.5: The Performance Gap Found in Case One



operations process. This is formalized as follow:

$$\Gamma_{DevOps} = (L, Q)$$

The length of the communications chain is measured by the number of handover points (denoted by H), and the number of stakeholders involved at each handover point (denoted by S). A handover point occurs between two process steps, where all the project information is handed over from one stakeholder to another one. Therefore the total number of handover points depends on the number of process steps (denoted by n). That is:

$$L = (H_1, S_1) \cup (H_2, S_2) \cup \ldots \cup (H_{n-1}, S_{n-1})$$

The quality of causality checks Q is determined by the number of causality checks (denoted by Nc) and the total number of releases (denoted by Nr) that are planned in the project. That is:

$$Q = (N_c, N_r)$$

The gap formalism is made on the basis of thorough analysis on the gap identified. Therefore the answer to research questions 4.2. is positive.

5.3.3 Bridging efforts

On the basis of the above analysis, efforts to bridge this gap should focus on improving the communication chain and performing causality checking on IT performance across the IT development process and mobile service operational process.

The DevOps gap comes from the mismatch between the scopes of IT development process and service operation process in IT-enabled SSC. Regarding the formalism for gap one, improvements could be done in relation to the communication chain and performance checks across different tiers, without changing the IT development process. In addition, service stakeholders need to raise awareness of the divergent domain knowledge in different tiers of the supply chain.

In general, the longer the communication chain is, the more information filters are found in business processes. The length of the communication chain is measured by the number of handover points and the number of stakeholders who are involved at each handover point. The more the both are, the longer the communication chain is. However, given the premise that the IT development process should not be changed, adjusting the number of both handover points and stakeholders is not an option in our bridging attempt. Instead, it is suggested to better regulate the communication chain. The daily communication amongst individuals should be better documented without influencing its flexibility and effectiveness. This is especially important to the ones from different departments. All the important decision points and the responsibilities of stakeholders involved should be properly documented.

It is worth noting the difference between the focuses of the IT development process and the service operations process. Nonetheless, the scope of the performance assessment in IT development process should be expanded and includes two types of causality checks. The first is to check the performance causality between agile releases delivered. Assessing the performance of one release alone is not enough, and it also suggests to check the impact of the delivered release on planning the following release. The other check is to assess the performance impact of the delivered product functionality on current service performance in operations.

Systems thinking is applied in proposing the bridging attempts above. The scope of the IT development process can be expanded by performing causality checks across release delivery and service operations. Given time and capacity constraints in this case study, it was unfortunately not possible to further check the impact of the bridging efforts in the innovation project in this case study. This concludes the answers to the research questions 4.3.

CHAPTER 6

CASE TWO: SERVICE OPERATIONS IN FIXED-LINE SERVICES

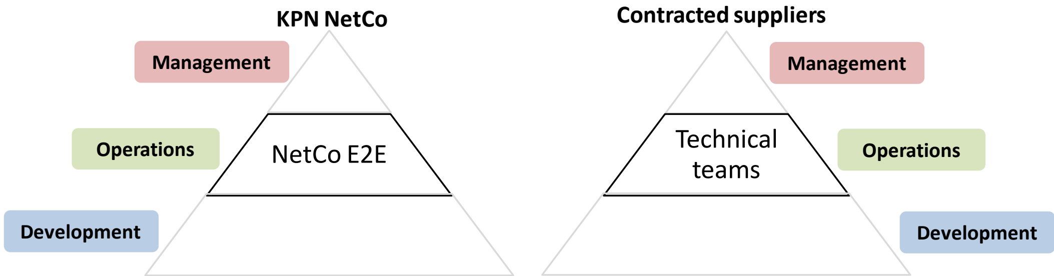
The contents presented in this chapter aims to answer the following research questions:

> **Q4.1. can the IT-enabled SSC studied be comprehensively and accurately modeled?**
>
> **Q4.2. can the operational performance issues in the IT-enabled SSC studied be successfully discovered and analyzed?**
>
> **Q4.3. can the chosen analytics improve the operational performance issues discovered?**

The enabling role of IT in KPN services was already seen in the previous case study. The core business of KPN, viz. the provision of telecom services to customers, are delivered through technical infrastructure, and are accessed and managed by IT applications. For KPN, the business does not function without service operations. The focus of the second case study is about the service operations in the fixed-line service of KPN.

KPN entered an innovation-driven transition period in the beginning of 2012. The innovation projects were carried out not only in the IT development (case one in chapter 5), but also in the service operations. The second case study is located within KPN NetCo and their contracted suppliers (Figure 6.1) where all the network operations of KPN's telecom services are carried out and collaboratively managed by them. The general subject in this case study is the performance of fixed-line supply chain operations and it zooms into one specific service operation, viz. the incident management.

Figure 6.1: The Scope of Case Two



The rest of this chapter is organized according to the improved service network diagnostic framework after case one (Figure 4.4). The case study is presented in two phases, namely the diagnostic phase and the therapeutic phase. In the diagnostic phase (section 6.1), the study starts with data collection (section 6.1.1), where a general synopsis of the outsourcing plan of service operations at KPN NetCo E2E is created. The large amount of case material on the KPN fixed-line service supply chain and the operation of incident management incident management is structured (section 6.1.2) by applying the metamodel and performance assessment criteria proposed in the framework. Furthermore, information on the key performance indicators of incident management is generated according to the proposed performance components (section 6.1.3).

When all the information is properly classified and filtered, the therapeutic phase (section 6.2) begins. The performance issues that are caused by outsourcing are introduced (section 6.2.1) and analyzed (section 6.2.2). Causal analysis and system dynamics simulation are applied to identify the second performance gap and to bridge it. The case study is concluded with the performance gap discovered and bridging attemps proposed (section 6.3).

6.1 Diagnostic phase

The focus in this case study is on service operations in IT-enabled SSCs, and KPN NetCo is the organizational unit that can provide information on this topic.

6.1.1 Data collection

The department of KPN NetCo E2E FO was responsible for the continuity of the fixed-line services in KPN. In the fixed-line SSC, it was difficult to foresee the impact of outsourcing on the performance of service operation during and after the innovation-driven transition period. Given this clear problem in the fixed-line service operations, the interviews and meetings were conducted with clear goals and about specific issues.

The case material was collected from 18 semi-structured interviews and meetings with informants from two departments in KPN NetCo E2E FO[1] (see Appendix A.4.1, Table A.3), as well as documentations and archival performance data from KPN NetCo E2E FO.

Case synopsis

KPN NetCo was the 'factory' that made all the telecom services and products of KPN technically possible. It was where operations of infrastructure and IT applications converged, and collaborated closely with many contracted suppliers to deliver and maintain those operations. More information on KPN NetCo performance management can be found in Appendix A.2.2.

KPN NetCo was gradually outsourcing several service operations of the fixed-line services to third party suppliers. The outsourcing plan was part of the innovation-driven transition that lasted a few year, and included a three-step transformation of operations and performance management. In the first step, almost accomplished in mid 2013, a full list of KPIs that were reported from the contracted suppliers to KPN was created and agreed by the departments or partners involved. In the second step, this KPI list needed to be assessed and adjusted according to the new requirements that were agreed in the outsourcing contracts. In the third step, when the outsourcing would become mature, the contracted suppliers would manage the operations independently and would only report the end-to-end KPIs instead of the operational KPIs back to KPN. After that, KPN would still control the suppliers and their performance via the service assurance.

Service operations at KPN NetCo E2E FO was managed according to ITIL processes[2]. **This case study chose to zoom in one specific operation: the incident**

[1] Please note that all the departments presented in this case were in their new names according to the outsourcing plan. They may be different from the ones listed in the interview list in Appendix.

[2] An overview of the service operations that were conducted at KPN NetCo E2E FO can be found in Appendix A.2.4.1

management, because it was an important operation and was directly in relation to service performance. Because of the outsourcing planned, the incident management process would be changed structurally in terms of organizational change and shift of responsibilities. Details of the incident management process and the outsourcing plan can be found in Appendix A.2.4.2.

6.1.2 Data structuring

The KPN fixed-line service is delivered and maintained by numerous service operations. The essential information on service operations in the fixed-line services needs to be further elicited and structured. By applying the service metamodel and performance assessment criteria that are proposed in the improved framework (Figure 6.1), the structure of KPN fixed-line SSC is unveiled, and the performance of its overall service and the chosen service operation, incident management, is assessed.

Modeling of KPN fixed-line service supply chain

The overall fixed-line service provided at KPN NetCo was called the KPN E2E service (Figure 6.2 [3]). Many stakeholders collaborated on the provision of this service, including the KPN business units, the service desk, the KPN NetCo E2E, the managed service suppliers and the maintenance & support suppliers. The customers subscribed to the service via the KPN business units, and contacted the service desk for questions and complaints. The KPN E2E service was made technically possible via the telecom network infrastructure, the managed services, the IT services and the monitoring systems, and was operated by the stakeholders involved. After the planned outsourcing, KPN NetCo E2E FO needed proper control power to communicate with all the contracted suppliers. The primary product of the KPN E2E service was the operations of the fixed-line telecom services. Table 6.1 presents the essential information on the KPN E2E service whose performance is assessed in Table 6.2.

Modeling of Incident management

Amongst all the service operations in the KPN E2E service (Figure 6.2), the scope of incident management is the life cycle of an incident: from the incident discovery till the restoration of the impacted service. The incidents of the fixed-line services were usually reported by the network surveillance or the customers, but

[3] Detailed description of this figure can be found to Appendix A.4.2

Figure 6.2: Structure of KPN Fixed-line Service Supply Chain

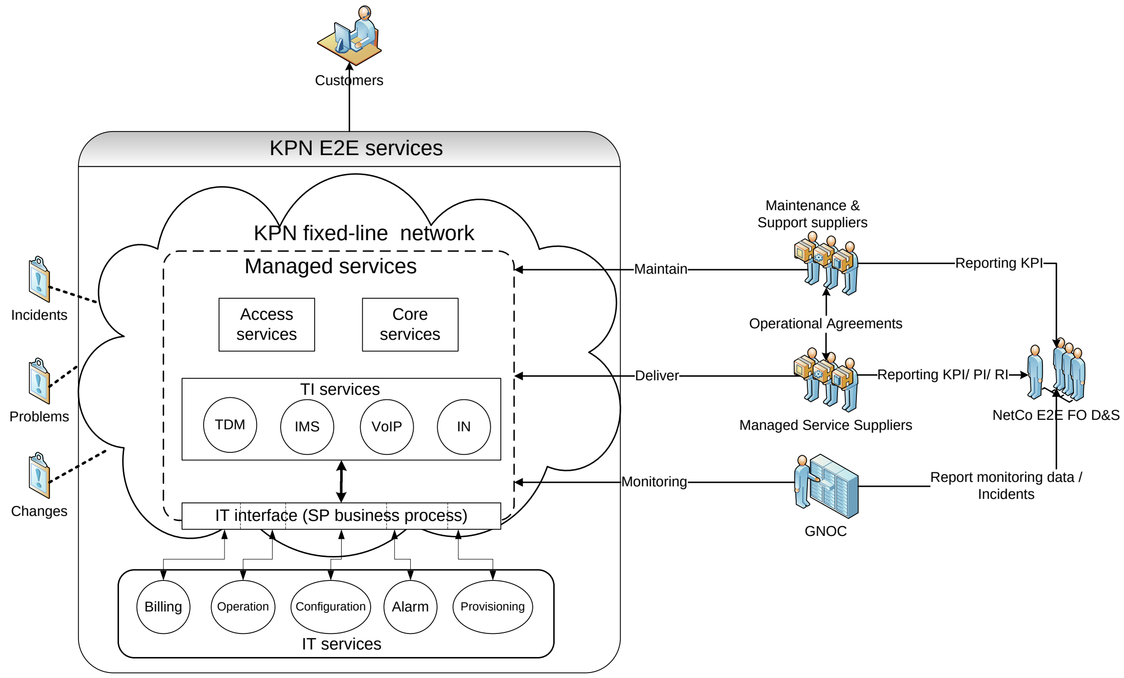


Table 6.1: Essential Information on the KPN E2E Service in Fixed-line

Modeling Component	Descriptions
Service	The KPN E2E fixed-line service
Customer	End users
Provider	KPN business units, service desk, KPN NetCo E2E, managed service suppliers, and maintenance & support suppliers
Production	The fixed-line telecom service operations
Technical capacity	The telecom network infrastructure, the managed services, the IT services, monitoring systems
Personnel capacity	Employee workload, knowledge level, control power over outsourcing

the operational process for incident management was requested by KPN NetCo E2E SQC[4] who therefore was considered as the customer of incident management. The product of incident management was the fixing of an incident that

[4]It is worth noting that not every incident was processed through the standard procedure, as some incidents with low impact on service performance could have been quickly fixed without notifying KPN NetCo E2E SQC.

Table 6.2: Performance Assessment of the KPN E2E Service in Fixed-line

Assessment Criteria	Descriptions
Customer involvement	The customers subscribed to the fixed-line service with the KPN business units and contacted the service desk when they had questions or suffered service impact.
Participant interaction	The KPN business units met monthly with KPN NetCo E2E to guarantee the internal SLAs. The service desk informed KPN NetCo E2E SQC of the incidents reported. The managed service suppliers and the maintenance & support suppliers reported to KPN NetCo E2E FO D&S about the service performance. They communicated intensively with each other during fixing incidents.
Human operation involvement	Personnel capacity (employee workload and expertise) was required from all the participants involved. For KPN NetCo E2E FO, in addition to that, extra efforts needed to be paid to controlling the outsourcing and to managing the contracted suppliers.
Software service involvement	The KPN E2E service could not run without the telecom network and all the supporting technical services or systems, including the managed services and the IT services, as well as the monitoring systems.
Granularity	From the perspective of customers: low, the customers only received the E2E service but could not see any operation of the service provided. From the perspective of the provider: high, numerous service operations needed to be managed to ensure a stable service provision.
Dependency	The KPN E2E service relied on a harmonious management of all the service operations. The service operations involved are introduced in section A.2.4.1.

was carried out by KPN NetCo E2E FO D&S and their contracted suppliers. The execution of an incident fixing was, depending on the incident, often done in the managed services and IT services, or sometimes in the network infrastructure. The actual workload that was required in this operation was determined by the productivity of the employees involved. Table 6.3 presents the essential information on the incident management. The performance of the incident management is assessed in Table 6.4, in order to further explain the essence of this service operation.

Table 6.3: Essential Information on Incident Management

Modeling Component	**Descriptions**
Service	The restoration of impacted services
Customer	KPN NetCo E2E SQC
Provider	KPN NetCo E2E FO D&S, managed service suppliers, and maintenance & support suppliers
Production	Incident fixing
Technical capacity	The telecom network infrastructure, the monitoring systems, the managed services, the IT services
Personnel capacity	employee workload and supplier productivity

6.1.3 Performance component generation

KPIs help to assess how well service operations are performed according to business requirements. Proper KPIs is not only for assessing service performance accurately, but also help to steer service operations towards the direction that is aligned with business requirements. A proper list of KPIs was strongly needed at the new department KPN NetCo E2E FO D&S, so that the performance of service operations could be better understood and managed during and after outsourcing.

In the supply chain of the fixed-line KPN E2E service, the overall operational performance was directly in relation to the joint performance of all the service operations involved (Appendix A.2.4.1). Since these service operations were managed according to ITIL processes, the lists of KPIs of every operation could be specified according to ITIL V3 service operation [181] and KPN's current KPIs framework. These lists can be found in Appendix A.4.3.

However, the KPI lists above did not take into consideration the impact of the outsourcing planned [5]. In this case study, it took a bigger scope that considered

[5] This will be further explained in the causal analysis of service operation performance in section 6.2.2

the changes brought by the outsourcing and generated a new list of KPIs by applying the performance components proposed in the framework. Given the case focus and the limited space, only the list (Table 6.5) of incident management is presented here.

When an incident occurred, the service received by customers could not perform normally. Customer call ratio was a very important indicator to the overall service performance and customer satisfaction. The sooner the incident was fixed, the sooner the service was restored at customers' side.

In order to ensure the incident fixing goes smoothly, it is necessary to have an efficient an effective operational process of incident management. In order to achieve that, GNOC should guarantee the quality of dispatching incident tickets; incidents should be sufficiently reported; the application of ticketing system should be clean and avoid creating double tickets; the administrative process and workflow system should be maintained complete as much as possible during the outsourcing.

The personnel capacity required included the incident management team and the level of expertise at GNOC. With respect to the outsourcing, the performance of incident fixing was influenced by the suppliers' competence and the control power of KPN during and after the outsourcing.

The technical capacity required in incident management was greatly influenced by the monitoring at different levels, viz. the service monitoring at SQC, the platform monitoring at GNOC and the system monitoring at supplier side.

6.2 Therapeutic phase

In this case study, the operational challenge was the difficulty of visioning the performance impact of outsourcing on service operations and on the overall supply chain performance of the KPN E2E service in fixed-line. Having all essential information generated and structured from raw case material in the previous diagnostic phase, a few performance issues came to light. In the therapeutic phase, the performance issues discovered (section 6.2.1) will be introduced first, then a series of analytics on the focal challenges will be provided (section 6.2.2).

6.2.1 Performance issues

The outsourcing planned brought changes to several operations in the fixed-line SSC. As described in Appendix A.2.4.2, the process of incident management would be re-organized and there would be shifts in responsibilities between

KPN and their contracted suppliers. The following difficulties in accomplishing this transition were found.

Transition from NOC to GNOC

The quality of dispatching tickets at KPN NetCo E2E NOC, or GNOC in near future, was important and the 'first time right' of the dispatch should be encouraged. For the new partner GNOC, it was difficult to decide the receiver of the tickets. During the transition period, lots of knowledge transfer was needed between NOC and GNOC in order to ensure the expertise level at GNOC. There was also technical transition of the ticketing system and administrative process in the workflow system that could cause temporal confusion in terminology or double tickets sent.

Management of supplier performance

Suppliers would play more important roles in service operations after the outsourcing was completed. Except the operations in relation to budget, financial forecasting, architecture, and technological knowledge that would stay in the control of KPN NetCo, the other operational issues would be under the responsibility of contracted suppliers. New outsourcing contracts would have particular emphasis on supplier performance in collaboration and the reporting mechanisms that would be used in service co-operations. It was imperative to understand and properly manage the supplier performance in the context of outsourcing.

Responsibility of KPN NetCo E2E FO D&S

The new department KPN NetCo E2E FO D&S was under construction and its main function was to steer and control all the service operations. Currently KPN NetCo E2E FO focused more on the supply side of service operations, but paid less attention to the demand side. KPN NetCo E2E FO D&S needed to expand the scope of its focus and got engaged in service agreement management, service level management, change management and partial contract management. This was a big challenge when the overall future picture of service operations was still not available and the new service performance measurements were not completely identified and applied during the outsourcing. The role of KPN NetCo E2E FO D&S still needed to be clearly defined, agreed and executed.

Shifts in managerial control power

Because of the outsourcing planned, there would be shifts in the managerial control power of which the performance impact was hard to foresee. Some operations teams in KPN NetCo E2E FO would be completely outsourced to suppliers and became the partners of KPN NetCo E2E FO D&S. The managers of those outsourced teams would be at the same managerial level as the KPN NetCo E2E FO D&S managers who used to be their superior managers. The control power of KPN NetCo E2E FO D&S would be influenced by the shifts of these managerial positions and the managers from both sides needed to adjust their responsibilities and ways of working in the new roles. Furthermore, proper control power would also be needed at KPN NetCo E2E FO D&S to manage the knowledge transfer and supplier performance management mentioned above.

6.2.2 Performance analysis

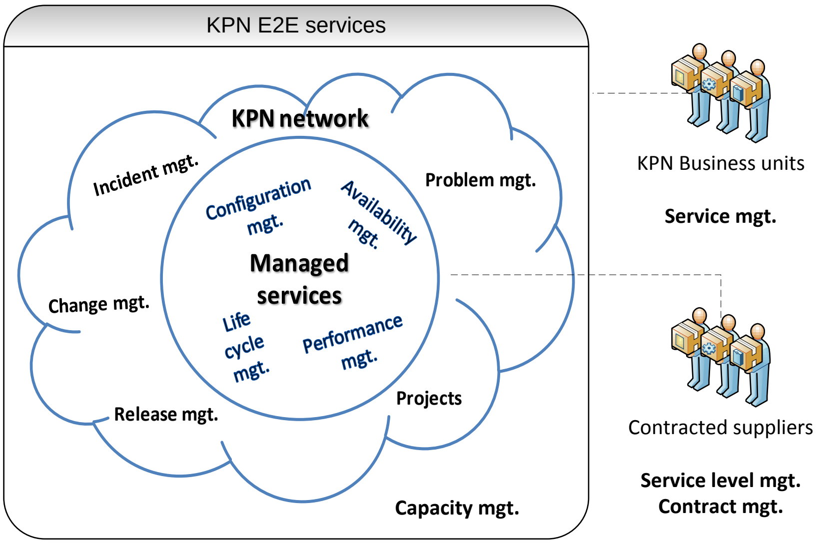
Regarding the performance issues mentioned above, the analysis began with presenting an overview of all the service operations managed at KPN NetCo E2E FO D&S and the typical KPIs of every operation in the operational processes. Then it zoomed into the incident management, and drew the causal relations amongst network events and the causal loops in incident handling process. The service operations that were managed separately were connected after being mapped in the causal diagram. In addition, a system dynamics simulation model was made to reveal the impact of various influential factors on the performance of incident management. Four sensibility analysis based on different scenarios were presented to show that how the change of influential factors could facilitate service operations during and after outsourcing. At the end, the analysis was concluded with the identification of the performance gap in this case study and the proposition of solutions.

Service operations in KPN fixed-line service supply chain

The objective of service operation is to make sure that the services are delivered effectively and efficiently [181]. Appendix A.2.4.1 introduces the thirteen service operations that run by KPN NetCo E2E FO. It is worth noting that these operations varied from each other in terms of thier focuses and scopes within the fixed-line SSC.

Regarding the overall supply chain structure of the fixed-line service (Figure 6.2), these operations were positioned in the supply chain in a semi-structured way (figure 6.3). The configuration management, the availability management, the performance management and the life cycle management mainly focused on the managed services, including TI infrastructure and IT systems in the network. The incident management, the problem management, the change management, the release management and the projects took care of the major network events and the overall network performance. The capacity management was concerned with the service fulfillment of the KPN E2E service. The other operations, namely service management, service level management and contract management, were in relation to the partners of KPN NetCo E2E FO, viz. KPN business units and the contracted suppliers.

Figure 6.3: Semi-structured Service Operations in KPN Fixed-line Service Supply Chain



Despite having the overview of all the service operations, it was still difficult to draw performance connections between them and the overall KPN E2E service. How the performance of these service operations influenced the fixed-line service performance received by customers was not clear. Thus a causal analysis on the service operation KPIs was demanded to reveal more insights into the performance connections.

Causal analysis of service operation performance

Having a smooth transition of service operations during outsourcing demanded an in-depth understanding of the causal relations amongst the KPIs of those operations. In this section, the causal analysis was conducted in **a four-step approach**. This approach was summarized during the application of causal analysis and was added to the service network diagnostic framework at the end of this case study.

It began with identifying the KPI list of every service operation, then built up the causal diagram that focused on the incident management. The causal diagram was further extended by linking more performance issues of other operations in the supply chain. Eventually it revealed the links between all the service operations and the performance of KPN E2E service in the fixed-line SSC.

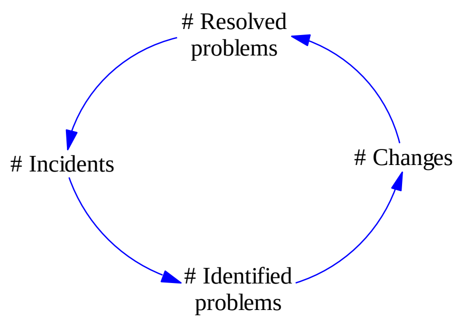
Step one: service operation KPIs

As already mentioned in section 6.1.3, the KPIs of all the service operations in the fixed-line SSC were defined based on ITIL V3 service operation [181] together with the KPIs framework of KPN. The complete lists of KPIs can be found in Appendix A.4.3.

Step two: causal loops in incident management

From the perspective of incident management, there were three major events in the fixed-line SSC: incidents, problems and changes. Incidents resulted from customer complaints (calls), system failures or errors in network operations. Problems could be unknown errors in the network some of which might be the root causes of incidents, and required changes to the managed services and network. More incidents might help to discover and identify problems, while resolving problems by implementing changes in the network might help to reduce the number of incidents. Figure 6.4 depicts these causal relations amongst these events.

Figure 6.4: Causal relations between incidents, problems and changes



There were many other factors that influenced the occurrence of these events and eventually influenced the performance of incident management. Some of these influential factors were measured by incident management, while others were undertaken by other operations. Incident management was involved in two causal loops (Figure 6.5) that were made of these performance indicators.

Incident fixing loop

Incidents came from customer calls and network alarms. Incident fixing consumed the available capacity of the incident management team. More available incident management capacity would possibly fix the incidents within shorter time. When it took longer to fix an incident, the impact on service performance also lasted longer. When there was continuous service impact received, customers would call to report the incident and the network monitoring systems would send alarms. Both customers and network surveillance would keep doing that until the service impact was taken away.

The supplier productivity had influence on the available capacity of the incident management team. It depended on 1) how properly the managed service suppliers and Maintenance & Support suppliers reacted to incidents and performed service restoration, 2) the quality of dispatching incident tickets. In addition, the communication between incident management team and suppliers determined how fast the suppliers would response and suppliers' competence determined the quality of their work.

Problem resolving loop

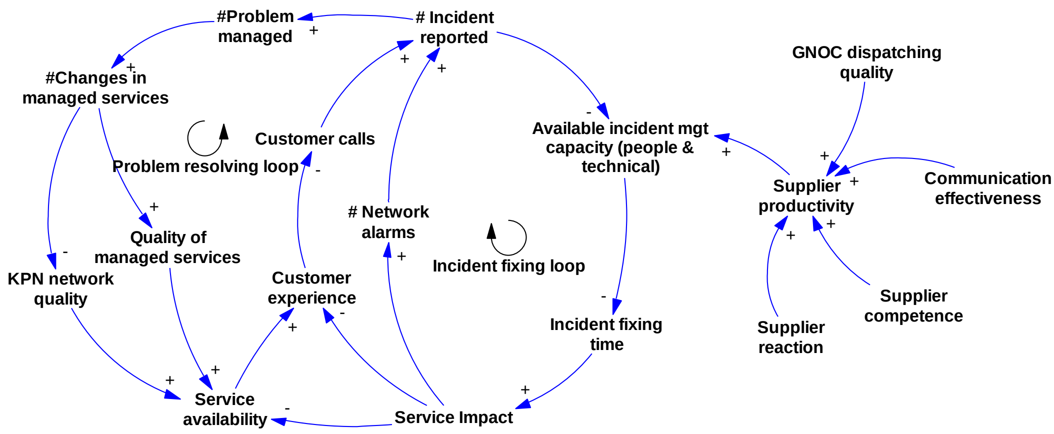
As indicated in Figure 6.4, resolving problems would eventually fix the root-cause of some incidents. More incidents reported helped to discover and identify problems. Problem resolutions required changes in managed services and he quality of managed services should be improved after implementing changes. However, new implementations could add complexity into the network and might affect its quality. The quality of network and managed services was in relation to service availability: the higher quality the longer the service availability was, and the service availability was directly perceived by customers.

Step three: causal loops with an extended scope

Besides the performance issues (Figure 6.5) that influenced the incident management directly, more driving factors from were explored in this step. Figure 6.6 depicts the extended causal loops in relation to incident management that included more factors from the KPIs defined in Appendix A.4.3 and some factors discovered additionally.

On the right side of the diagram, more performance issues that influencd the communication effectiveness in incident management were introduced. The level of partner relationships, in general, influenced the communication between KPN and the suppliers. KPN and the suppliers became familiar with the operations by sharing their knowledge about the network and managed services. The quality of reporting was important, because it de-

Figure 6.5: Causal Loops in Service Operations (from the perspective of incident management)



termined how properly performance issues were communicated between suppliers and KPN. All of these three factors positively influenced the communication effectiveness. In the extended diagram, it also pointed out the causal connection between the 'incident fixing time' and the 'service level agreement violation'. The longer the incident fixing was, the more likely the agreed service level was violated.

On the upper-left side of the diagram, projects and releases were added and linked to the network events (incidents, problems and changes). Projects were initiated by the changes planned in managed services or were to solve identified problems. Releases came from projects or planned changes. The implementation of releases helped to solve problems and to improve the quality of managed services.

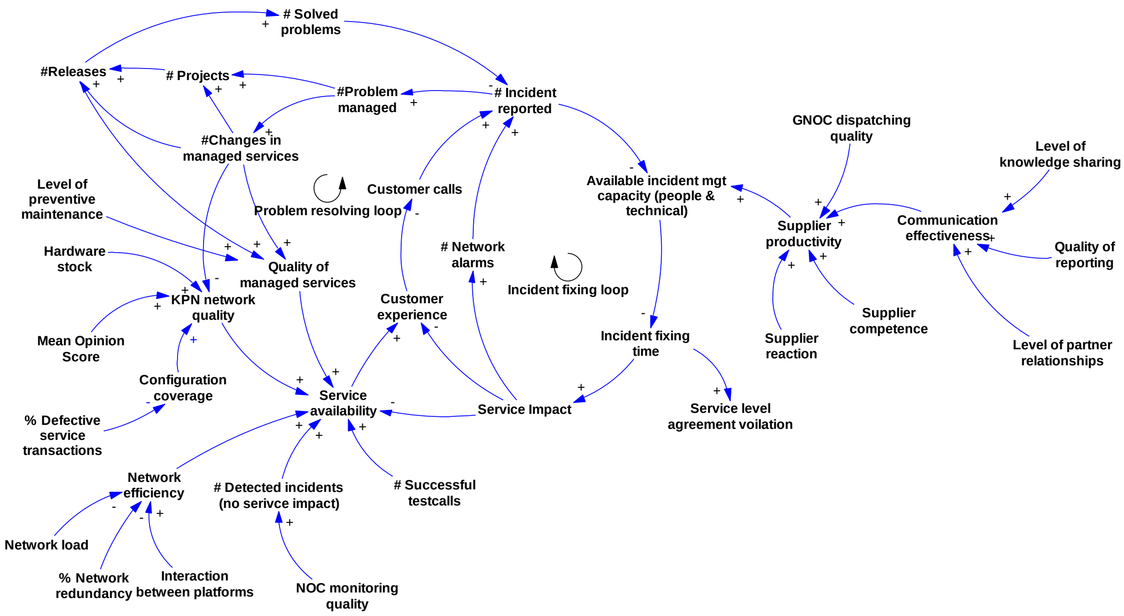
On the lower-left side of the diagram, more technical performance indicators were linked to the 'managed service quality', the 'network quality' and the 'service availability' respectively.

Please note that the influential factors presented in Figure 6.5 and Figure 6.6 were **not the exact duplication** of the KPIs that were defined for every service operation in Appendix A.4.3. It was because that some additional factors were discovered in order to causally connect the performance of different service operations. Those factors that did not belong to any predefined KPI list in Appendix A.4.3 were the **'performance bridges'** in the fixed-line SSC.

Step four: mapping of service operations in the extended causal loops

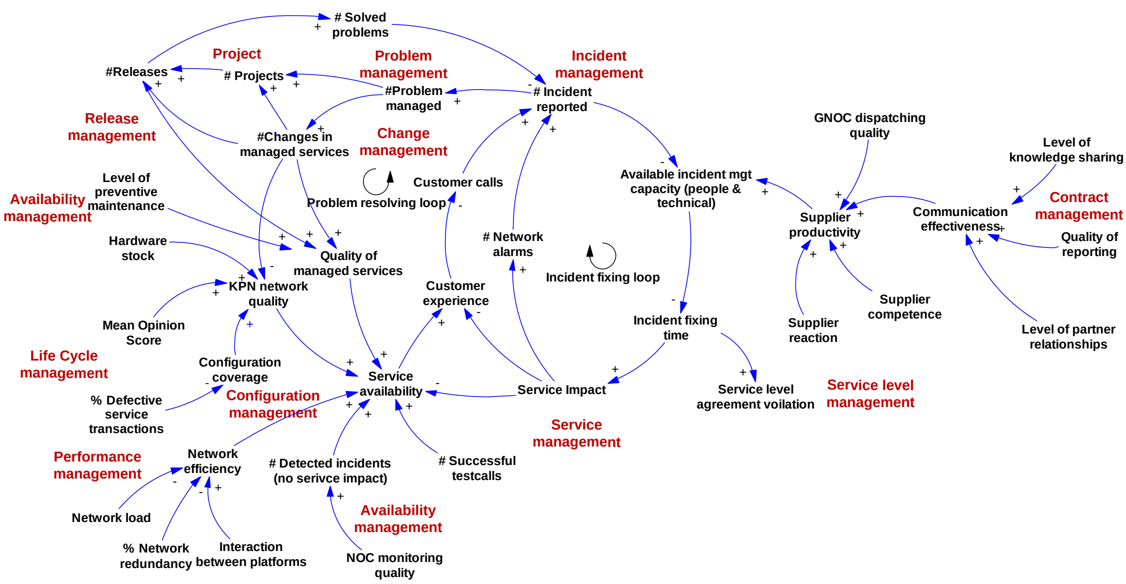
Having the extended causal loops created (Figure 6.6), more service operations could be mapped into this diagram. Certain service operations could be recognized in the causal loops by their associated KPIs structured. The

Figure 6.6: Extended Causal Loops: More Performance Issues in Fixed-line Service Operations



mapping (Figure 6.7) displayed twelve out of thirteen service operations within the responsibility of KPN NetCo E2E FO D&S. The capacity management was not given a specific position in this picture, because it provided monthly forecast on both finance and personnel capacity for all the service operations that were included here.

Figure 6.7: Extended Causal Loops in Service Operations: Mapping of Fixed-line Service Operations



Simulation modeling of Incident Management

In this section, a system dynamics model of incident management was built based on the causal analysis performed above. The purpose of building this model was to reveal the impact of various influential factors on the incident fixing rate and to facilitate the operations towards desired performance in the changing environment.

Regarding the causal analysis on the incident management (Figure 6.5), the outsourcing undertook in incident management would mainly affect the delay of incident fixing. If the fixing delay was longer than what had been specified and agreed by both KPN NetCo E2E FO D&S and their contracted suppliers, the operational SLA would be violated.

The KPI 'incident fixing time' was an aggregated performance of actions that were taken during the incident handling process (Figure A.12). This process involved the GNOC monitoring center, the technical teams and 3rd line suppliers. The efficiency of incident management was influenced by the available capacity of the incident management team, which was influenced by the available FTE and the supplier productivity. The supplier productivity and its influential factors in the incident handling process were further explained below:

GNOC dispatching quality

The ticket dispatching quality was determined by the **expertise level at GNOC** and the **maturity of the work flow system** that were used in incident management. Sufficient knowledge about the service operations and responsible suppliers needed to be guaranteed at GNOC. The work flow system should have one, clean ticketing system without the risk of creating double tickets. The incident tickets should be uniquely registered and tracked in the ticketing system: Astrid. The administrative process should be conceptually and terminologically clear and standard. It was important to guarantee the accessibility of the workflow system during the transition period until the administrative process was complete.

Monitoring systems

Monitoring had always been crucial in service operations. While the outsourcing planned was ongoing, there was and would be service monitoring performed by KPN NetCo E2E SQC, platform monitoring performed by GNOC and system monitoring performed by suppliers. Since the monitoring performed by suppliers gave prompt signaling, suppliers could take care of incidents when they were still at the **system level**. Monitoring performed at **platform level** and **service level** provided real-time running status of the platform and services. If a performance anomaly was detected by the monitoring, it sent network alarms. In addition to customer calls, the network alarm was another main source to report incidents. Good and proactive monitoring would discover more (potential) incidents before severe service impact were caused and received by customers.

Supplier productivity

The supplier productivity referred to supplierâ€™s power to produce or their quality of being productive. It was directly determined by their **competence**, in terms of their ability in performing the fixing activities. In the context of outsourcing, both KPN's **control power** and the **communication effectiveness** between KPN and suppliers had big impact on the performance of suppliers, because these factors revealed the soft issues in an outsourcing environment. The effectiveness of organizational communication reflected the smoothness of operations conducted. The extent KPN was in charge of service management implicitly showed the control power of KPN in decision makings. Another influential factor to suppliers' productivity was **their reaction** to the signaling in monitoring.

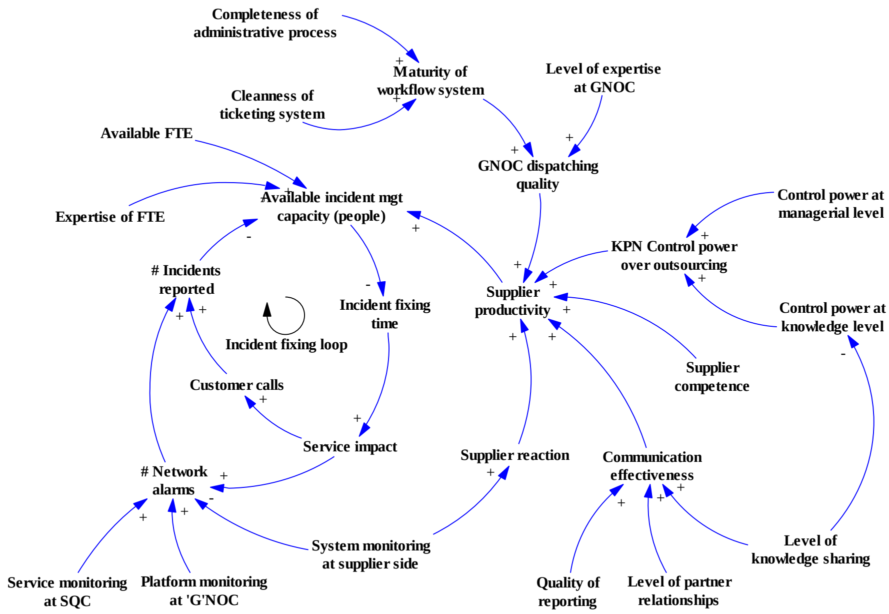
In addition, the supplier productivity was also influenced by the quality of ticket dispatching and the monitoring systems. The suppliers worked more efficiently if they were not distracted from receiving wrong incident tickets. Despite the central platform monitoring performed by GNOC, the suppliers also conducted monitoring at system level. If the monitoring system preformed by suppliers proactively gave signaling about potential risks, the suppliers would become more reactive to incidents and solve them before impact was caused at customer level.

Having all the above analyzed, more detailed factors that influenced the incident fixing rate were causally structured in the incident fixing loop (Figure 6.8). The complete simulation model can be found in Appendix A.4.5.

Performance assessment by simulation

Given the role of customer experience in driving service management, the customer-centric perspective was adopted in the performed analytics. The simulation model (Appendix A.4.5) built in this section was used to check the SLA violation resulting from the incident fixing. The SLA violation was defined as the discrepancy between the actual incident fixing time and the agreed SLA. As long as the incident fixing was undertaking, the customer would be perceiving the service impact that was caused by the incident. Thus the SLA violation had to be kept to a minimum.

Figure 6.8: Causal Relations in Incident Fixing Loop



Four sensibility analysis were conducted to test the impact of four influential factors, respectively, on the SLA violation. In each sensibility analysis, three running results were compared to show how the changes of one factor would influence the performance of incident fixing. The data used in the simulation model was partially adopted from the historical data of incident report rate. In order to reveal the general trends of situations after outsourcing was complete, some data in this experiment was made based on estimations and did not provide accurate predictions about performance.

Regarding the difficulties in perceiving performance impact in service operations in relation to the outsourcing planned (section 6.2.1), four influential factors were chosen: level of expertise at GNOC, control power over outsourcing, monitoring at 2nd line supplier and supplier competence.

S01 Increasing the level of expertise at GNOC

The level of expertise at GNOC was set at 0.4, 0.7 and 1.0 in the three runs respectively. While the incident report rate remained the same (the upper left graph in Figure 6.9), higher level of expertise at GNOC led to better quality of ticket dispatching was (the upper right graph in Figure 6.9) and higher the incident fixing rate. When the level of expertise at GNOC was higher than 0.7, the incident fixing rate (the middle left graph in Figure 6.9) was significantly increased. Meanwhile, better dispatching quality at GNOC led to an increase of 'first time right' in ticket dispatching. Thus more incidents were waiting to be fixed at the right supplier. That explained that although the incident fixing rate was increased, the incident backlog (the middle right graph in Figure 6.9) did not change much in the second and third run. Overall, higher level of expertise at GNOC would lead to an improved performance of incident fixing and adjust violated SLA back to minimal faster (the bottom left graph in Figure 6.9).

S02 Increasing control power over outsourcing

The control power over outsourcing was set at 0.4, 0.7 and 1.0 in the three runs respectively. With the same incident report rate (the upper left graph in Figure 6.10), increasing control power over outsourcing would significantly improve the incident fixing activities during the first few weeks. The incident backlog (the upper right graph in Figure 6.10) had a less steep rising curve due to the higher incident fixing rate (the bottom left in Figure 6.10) during first couple of weeks. The SLA violation (the bottom right graph in Figure 6.10) also became smoother before it reached the minimal around week 7. However, the control power over outsourcing only partially determined the outsourcing environment of the incident fixing process and was not directly in relation to any specific operation. Therefore, when there was a sudden increase in the incident report rate around week 16 - 17, the incident fixing rate could not be adjusted timely, which results an increase in the incident backlog. This implied that it did not guarantee a good, long term performance if only adjusting the control power over outsourcing for one time. In order to cope with changes in the outsourcing environment, frequent adjustment of control power was needed.

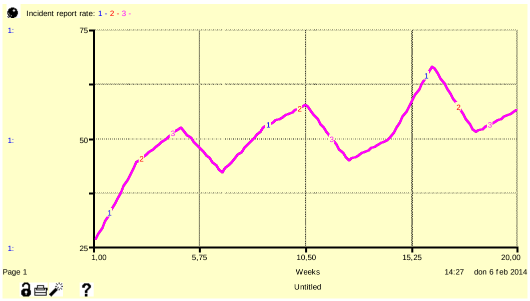
S03 Increasing monitoring at 2nd line supplier

The monitoring at 2nd line supplier was set at 0.4, 0.7 and 1 in the three runs respectively. Better monitoring quality implied that more network alarms would be sent out and more incidents would be reported before any impact was perceived by customers. The increase of monitoring at 2nd line supplier led to a corresponding increase of the incident report rate (the upper left graph in Figure 6.11) and of the incident backlog (the upper right graph in Figure 6.11). At the same time, the incident management productivity 2nd line (the middle left graph in Figure 6.11) was also increased as the 2nd line supplier became more reactive due to the improved monitoring level. Better productivity increased the incident fixing rate (the middle right graph in Figure 6.11). This explained why the SLA violation (the bottom left graph in Figure 6.11) only got minor influence around week 4 when the incident backlog reached its peak, but quickly got adjusted back and was kept at the same level in the 3 run.

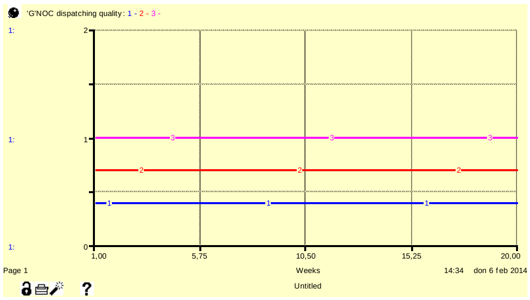
S04 Increasing supplier competence

The supplier competence was set at 0.4, 0.7, and 1.0 in the three runs respectively. The level of supplier competence influenced the supplier productivity. While the incident report rate (the upper left graph in Figure 6.12) remained the same during the 3 runs, difference could be seen in the incident backlog (the upper right graph in Figure 6.12) due to the increased incident management productivity 2nd line (the middle left graph in Figure 6.12). Higher incident management productivity 2nd line led to higher incident fixing rate (the middle right graph in Figure 6.12) during first couple of weeks and left less pressure on the incident fixing later. That explained why the incident backlog had less steep rising curve when the supplier competence was higher during week 3-6, while the corresponding incident fixing rate was also lower during the same period. The SLA violation (the bottom left graph in Figure 6.12) became smoother before it reached the minimal around week 6.

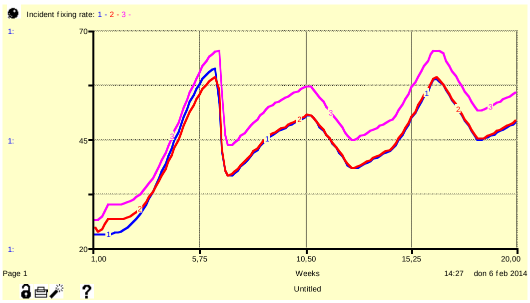
Figure 6.9: Performance Impact: S01 Increasing the level of expertise at GNOC



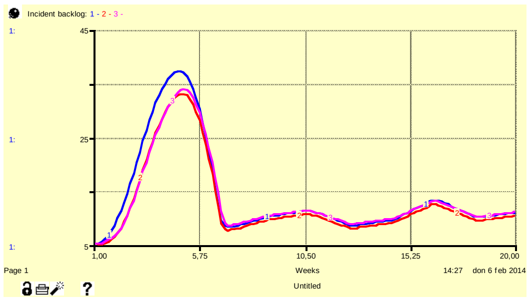
Incident report rate



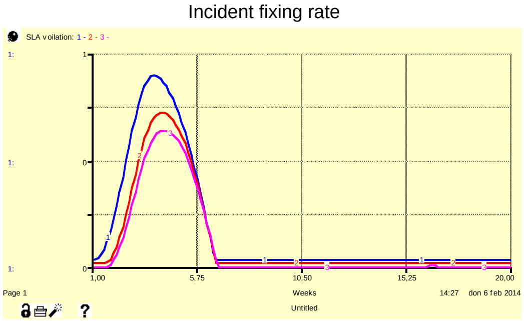
GNOC dispatching quality



Incident fixing rate

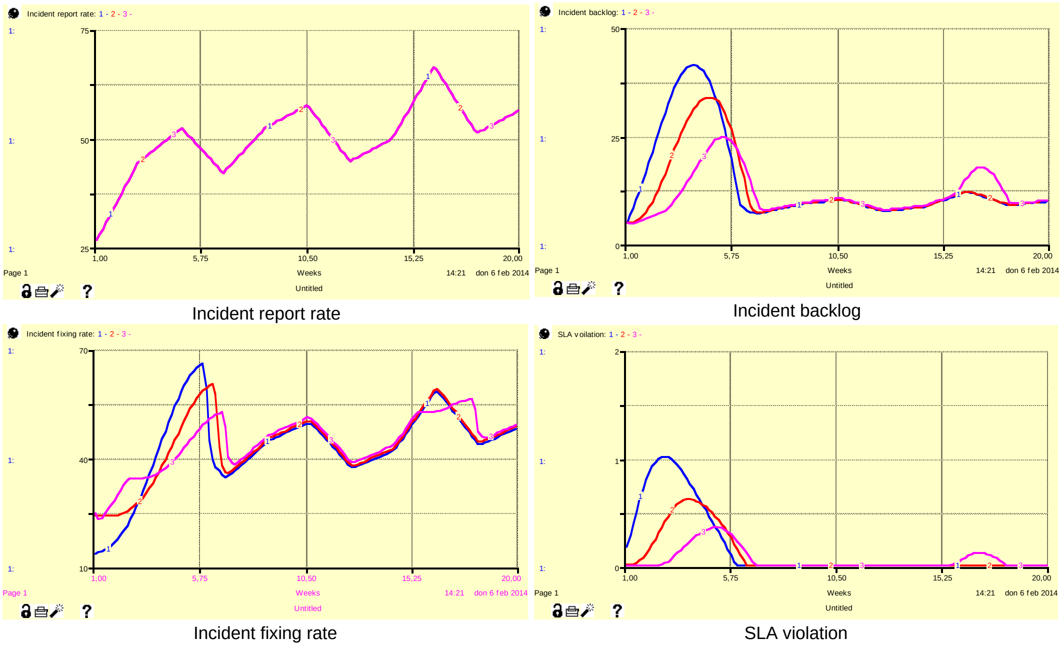


Incident backlog



SLA violation

Figure 6.10: Performance Impact: S02 Increasing control power over outsourcing



6.2.3 Conclusion

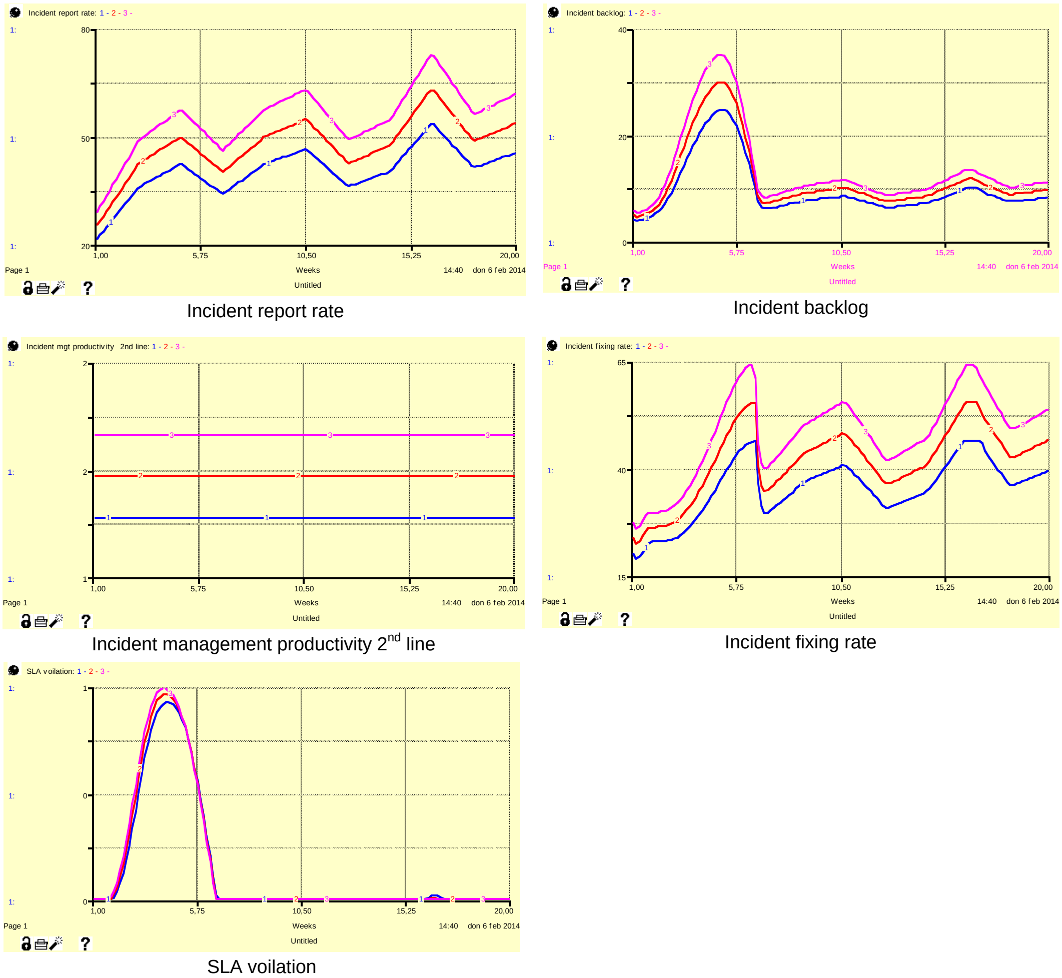
The thorough performance analysis presented in this section resulted from the application of casual analysis and system dynamics simulation modeling. The causal analysis generated and structured performance influential factors step by step and revealed the performance causal link amongst all the service operations in the fixed-line E2E service. The simulation model was built based on the causal analysis and tested four scenarios to assess the performance impact of changes that were in relation to the increasing importance of supplier performance in outsourcing.

Content wise, the performed analytics - the causal analysis and simulation model - revealed the performance gap in the fixed-line SSC studied: the causal impact of service operations performance was missing in the context of outsourcing. The scenarios that were tested in the simulation model provided guidelines to bridge the gap.

6.3 Summary

The outcome of this case study reveals the performance gap among the service operations in the fixed-line SSC, and suggests bridging attempts on closing the

Figure 6.11: Performance Impact: S03 Increasing monitoring at 2nd line supplier



gap. This section summarizes the answers to the research questions raised at the beginning of this chapter.

6.3.1 The service operations gap

The second case study focuses on how the diverse service operations should be 'bridged' in the context of outsourcing. This performance gap is located within the operations that are carried out by different operational departments from the service organization and the contracted suppliers (Figure 6.13).

The supply chain of the fixed-line E2E service was a very complex network of many service operations separately managed and participants involved. In practice, every service operation had their clearly defined responsibility and a set of KPIs to measure their performance. Although KPN NetCo E2E had an overview of all the service operations for the provision of the E2E service, the performance

Figure 6.12: Performance Impact: S04 Increasing supplier competence

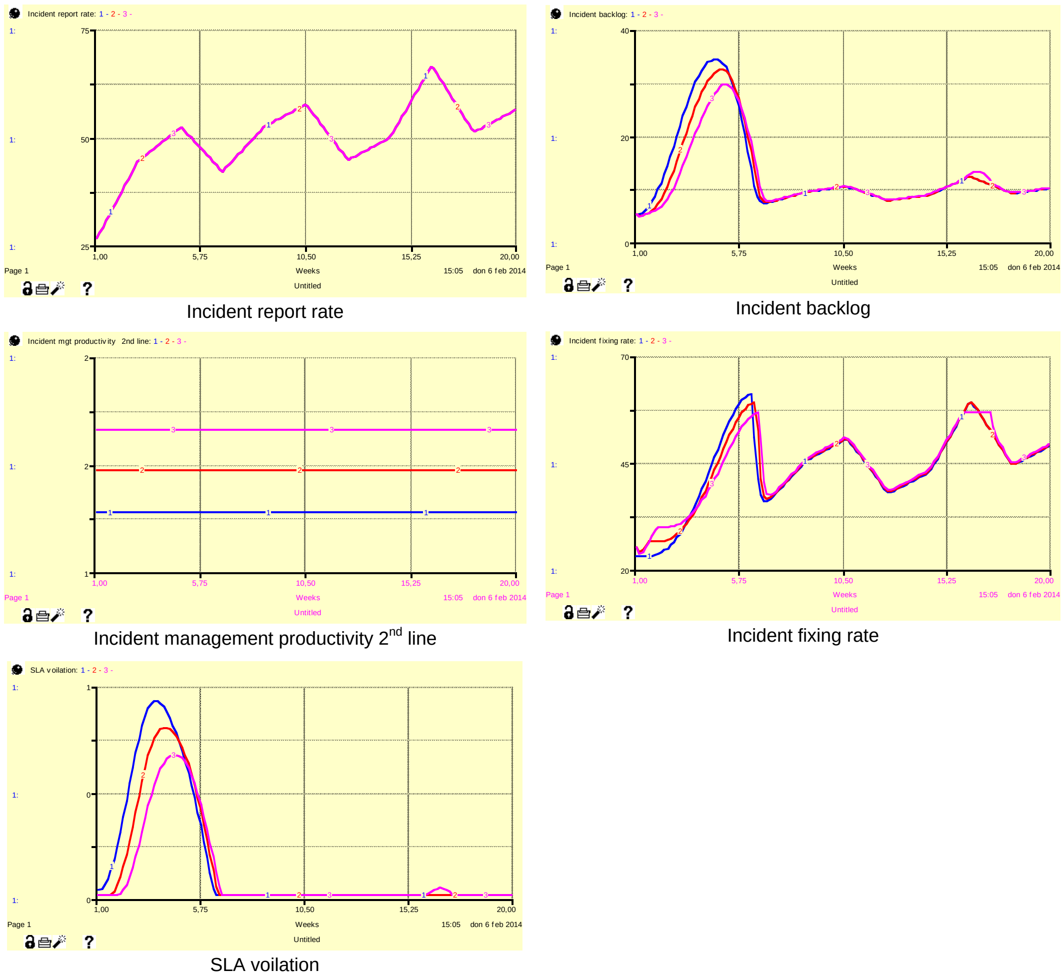
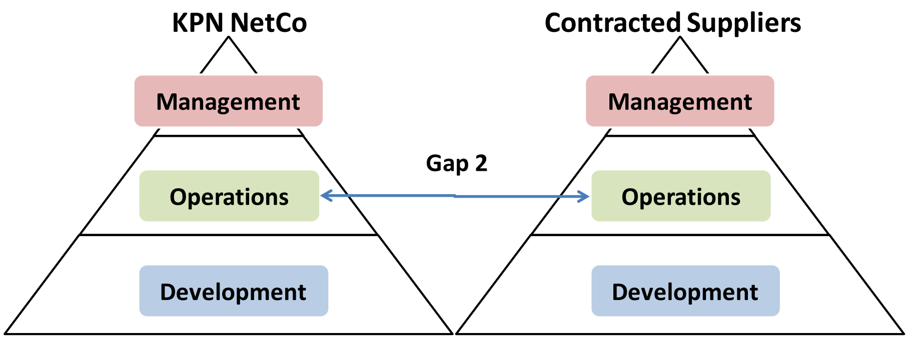


Figure 6.13: The Performance Gap Found in Case Two



links amongst these service operations and the one between them and the E2E service were not in this scope. The difficulties in managing such complex supply came from lack of a holistic understanding of the causal relationships between all the operations and the E2E service. Especially in the context of outsourcing, these service operations were performed by different suppliers which made it more challenging to capture the causal loops amongst them.

The causal analysis focused on the incident management and took a customer-centric perspective. It revealed the short-term incident fixing loop and the long-term problem solving loop by linking relevant performance issues causally. Then, it extended the scope of incident management and associated more performance issues and defined KPIs to it. Thus, all the service operations, regarding their KPIs, could be identified in the same causal diagram and the causal relationships among them were revealed.

The simulation modeling gave an exemplary overview of how the outsourced operations could be considered and managed holistically. The scenarios and analysis presented in section 6.2.2 indicated the importance of suppliers' behavior to the operational performance of the incident management in the context of outsourcing. Bridging efforts were discussed in relation to these scenarios.

The discovery of the service operations gap is made possible on the basis of comprehensive and accurate case study and modeling. Research questions 4.1. is answered by the identification of this gap.

6.3.2 Gap formalism

Having all operations enabled by IT applications implies that there is no service available for customers, if any of these IT applications stops functioning properly. The service performance perceived by customers lies in a collective alignment of all the service operations. The challenge in operating such services is twofold. Any malfunction of the IT applications may directly lead to performance impact at customer level. In addition, there is no time window for shutting down the IT applications, whenever any change needs to be made to such services. As a result, very high reliability is demanded of the IT applications.

There are three aspects to facilitating the reliability of IT applications. The first is the technical condition of the IT applications themselves. The more mature the applications are, the more reliable they are. The second consideration is from the administrative perspective. The more complete the administrative process involved in operating these IT applications, the more reliable the applications are. Additionally, monitoring systems provide good indications of the behavior of applications. Therefore the better quality the monitoring systems, the more reliable the IT applications can be.

An outsourcing context for IT-enabled service operations means that these operations are managed separately by different suppliers who may be at different remote locations. Supplier productivity has a strong influence on the service performance delivered, and two aspects can be distinguished, namely supplier competence and supplier management. The first aspect points directly at the level of expertise the supplier holds, which is quite straightforward in its association with productivity.

However the actual supplier productivity that is perceived in service operations depends on how well the operations are managed. Each supplier has clearly defined responsibilities and performance measurements, however it is difficult for any of them to see service performance as a whole from the customer perspective. Managing outsourced IT-enabled service operations requires effective communication amongst all the operations teams so that the performance of each service operation is understood. It is also important to have proper control of the outsourcing situations, to enable smooth collaboration amongst all the suppliers. Service operations should continuously offer reliable services, while customers experience no difference and no impact on quality from the fact that the service operations have been outsourced.

The service operation gap in the context of outsourcing is measured in terms of the reliability of IT applications (denoted by Rit) and the productivity of contracted suppliers (denoted by Ps). A formalism of this gap is:

$$\boldsymbol{\Gamma}_{\boldsymbol{OpsOutsourcing}} = (R_{IT}, P_s)$$

The IT reliability lies in the maturity of IT systems (denoted by Mit), the completeness of administrative process (denoted by Ca), and the quality of monitoring (denoted by Qm). Then that is:

$$R_{IT} = M_{IT} \cup C_a \cup Q_m$$

The measurement of supplier productivity consists of the level of expertise (denoted by E), the communication effectiveness amongst stakeholders involved (denoted by Ce), and the control of outsourcing (denoted by Co). This can be formalized as:

$$P_s = E \cup C_e \cup C_o$$

The above gap analysis and formalism sufficiently provide positive answers to the research question 4.2.

6.3.3 Bridging attempts

The bridging attempts below conclude the answers to the research question 4.3.

The service operations gap appears in outsourced IT-enabled service operations.The main influential factors to this gap are the reliability of IT applications and the productivity of contracted suppliers. IT-enablement ensures continuous service delivery, while compels all service changes to be done in an open-heart operation. The context of IT outsourcing indicates that the role of contracted suppliers in service operations is very important and influences the collective performance of services. The efforts paid on these issues is explained below.

IT reliability could be enhanced from both technical and non-technical perspectives. The technical backbone of reliable IT is in relation to the maturity of IT systems and the quality of monitoring in service operations. The usage of IT applications should be assisted with an effective and efficient administrative process. In the context of outsourcing, IT maturity implies that all IT systems should be free of redundancy and they should be accessible by all authorized contracted suppliers. Service monitoring should be provided at different levels, viz. at the system level, at the platform level and at the network level. In order to guarantee the efficiency and effectiveness of the administrative process, all contracted suppliers should be informed and aligned with a standard procedure that is conceptually and terminologically clear.

The productivity of all contracted suppliers is another indicator to this performance gap. Since personnel capacity is one unique factor to SSC performance [77], the productivity of suppliers in IT-enabled service operations is closely associated with people's capability and interactions with IT systems and depends on the quality of IT systems that are used. The quality of IT systems is considered equivalent to the IT reliability mentioned above. The expertise of suppliers is a 'hard' criteria to measure their productivity. In addition, the productivity of suppliers is also determined by their control power in outsourcing and how effective their communication with service owner is.

Table 6.4: Performance Assessment of the Incident Management

Assessment Criteria	Descriptions
Customer involvement	KPN NetCo E2E SQC was responsible for monitoring the services and detecting severe incidents. It was the initiator of the calamity procedure for fixing incidents, but was not involved in actual executions of the fixing process.
Participant interaction	KPN NetCo E2E SQC worked as the interface between GNOC and KPN NetCo. GNOC interacted with the suppliers of managed services by dispatching incident tickets. KPN NetCo E2E FO D&S received performance reports from both managed service suppliers and maintenance & support suppliers. The maintenance & support suppliers were contacted by the managed service suppliers for fixing incidents if necessary.
Human operation involvement	Personnel capacity (employee workload) was required from all the participants involved in initiating the calamity procedure, dispatching the incident tickets and fixing the incidents. The productivity of the suppliers involved had big influence on the performance of incident management.
Software service involvement	The monitoring systems were used for network surveillance. The ticketing system was used to record the incidents and the communication in incident management. Depending on the root cause and impact of incidents, the network infrastructure, the managed services and other IT services could be needed as well.
Granularity	Looking at the overall structure of service operations in fixed-line services: low, the incident management was for restoring impacted services. Looking into the incident handling process: high, the operations in incident management included network surveillance, dispatching incident tickets, and the execution of incident fixing.
Dependency	The incident management relied on an effective network surveillance, an assured ticket dispatching and the accomplishment of incident fixing.

Table 6.5: Performance Components of the Incident Management

Performance Components	**Performance Indicators**
Customer Satisfaction	- customer call ratio - incident fixing time
Network bottleneck / capacity allocation	- GNOC dispatching quality - quality of reporting - cleanness of ticketing system - completeness of administrative process - maturity of workflow system
Personnel Capacity	- available incident management capacity - level of expertise at GNOC - supplier competence - control power over outsourcing
Technical Capacity	- service monitoring at SQC - platform monitoring at GNOC - system monitoring at supplier side

CHAPTER 7

CASE THREE: SERVICE MANAGEMENT IN iTV SERVICES

The contents presented in this chapter aims to answer the following research questions:

Q4.1. Can the IT-enabled SSC studied be comprehensively and accurately modeled?

Q4.2. Can the operational performance issues in the IT-enabled SSC studied be successfully discovered and analyzed?

Q4.3. Can the chosen analytics improve the operational performance issues discovered?

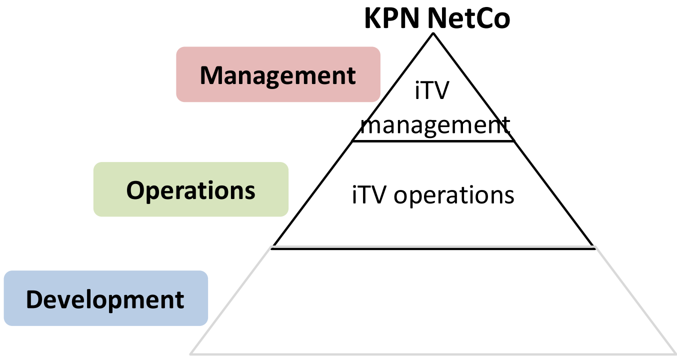
Service organizations are moving towards customer-centric business. The adoption of a customer-centric perspective is useful to structure and align service operations (case two in chapter 6). With what has been learned in the previous two case studies, the processes of IT delivery and IT-enabled service operations need to be better aligned with respect to the service performance that is received by customers. This motivates the research to look into the managerial level in this case study, and to examine how service strategies should be made by aligning development and operations.

The third and the last case study presented in this thesis was still conducted within KPN NetCo and focused on the management of service innovations and operations in KPN's interactive television (iTV) service (Figure 7.1). The iTV service [1] was one of KPN's latest innovative solutions that had successfully integrated internet and TV. The customer response to iTV service had been very positive and the subscriptions had

[1] More information on KPN iTV service can be found in Appendix A.2.5.1

been increasing steadily. In order to keep and expand the success, more innovation projects were launched to further advance this service. Meanwhile, how to keep the operations up with the fast-paced innovation was vital to the service management.

Figure 7.1: The Scope of Case Three



The improved service network diagnostic framework after case two (Figure 4.5) has been applied in this case study. The two-stage structure in the proposed framework is still found in the rest of this chapter. In the diagnostic phase (sec:case3diagnostic), it starts with data collection (section 7.1.1), where a general synopsis of the challenges in service management at KPN's iTV service is created. The essential information on the core iTV service operations is structured and the performance of these operations is assessed (section 7.1.2) by applying the service metamodel and performance assessment criteria proposed in the framework. Furthermore, information on the performance indicators of these service operations is generated and categorized (section 7.1.3) by applying the proposed performance components.

When all the information is properly classified and filtered, the therapeutic phase (section 7.2) begins. The challenges in managing the iTV SSC is perceived (section 7.2.1) and analyzed (section 7.2.2). The case study is concluded with the identification of the third performance gap and the proposal of bridging attempts (section 7.3).

7.1 Diagnostic phase

The topic in this case study is on the service management in the iTV SSC that operationalize the provision of iTV services. The service management team need to understand how customers perceive the service quality and how organizations provide the service, as well as by ensuring the quality of services so that all the objectives of the parties involved are met [182].

7.1.1 Data collection

iTV was one of KPN's innovative service solutions that added data services to traditional television technology. Behind the big success, there ran one of the most complex supply chains to deliver the iTV service to customers. NetCo FO TV&Media was the department that was responsible for the serivce management of iTV services.

The problem encountered by the iTV management team was clear: the continuous service incidents caused the service operations team under severe pressure and the service performance impacted. This problem led the study focus to examining the root causes and fixings to those incidents in iTV services. The scope of this case study crosses the managerial and the operational level, therefore the key informants included service managers from both the innovation and the operation teams at NetCo FO TV&Media management.

Complex case information was received via the triangulation of data collection, including 16 semi-structured interviews, 2 model-building workshops [177], documentations and performance data of iTV services. Given the clear problem in the iTV service management, all the interviews and workshops were conducted with clear goals and about specific issues. A list of all the interviews and workshops can be found in Appendix A.4.6 Table A.18.

Case synopsis

The activities in the iTV SSC[2] were grouped into three parts, namely the iTV innovation, the iTV operation, and the iTV problem management. The iTV innovation was responsible for the development of iTV service that included adding new functionality and improving existing features in iTV products. The iTV operation made sure the quality of iTV services at a stable level throughout the delivery network. The iTV problem management tackled any type of problems that were in relation to iTV services, both technically and non-technically.

Despite the expanding customer base and successful launch of new innovation projects, the iTV service management faced increasing pressure from a series of severe incidents during the period of 2010-2013. Regarding the level of service impact at customer base, incidents were coded in color blue, yellow, orange and red, from less severe to the most severe level[3]. The iTV operation played an important role in the incident fixing process[4]. The operational pressure on the iTV operation was accumulated significantly during 2010-2013. The iTV management team, unfortunately, could not improve that situation. The attention in this case study was drawn to the

[2] More information on iTV service management can be found in Appendix sub:itvsm

[3] More information on the emergency communication mechanism Be-Alert at KPN can be found in Appendix A.2.5.3

[4] The incident fixing process at iTV operation is introduced in Appendix A.2.5.4

operational process of incident fixing and its impact on managing the whole iTV SSC.

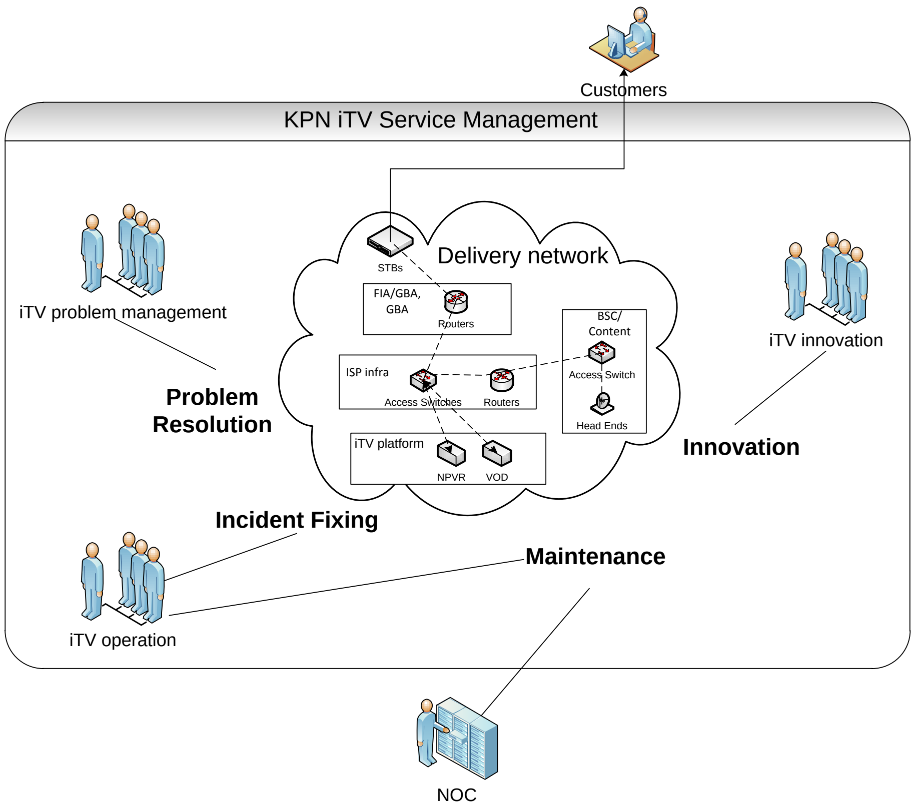
7.1.2 Data structuring

The essential information on the service management in iTV SSC was generated from the information collected by applying the service metamodel and the performance assessment criteria. The iTV service was one composite service that could be further divided into four services: iTV innovation service, iTV maintenance service, iTV incident fixing service and iTV problem management service.

iTV service

The iTV service (Figure 7.2) was provided by KPN NetCo FO TV&Media and was received by customers. The performance of iTV service relied on good management of innovations, operations and problems. The service delivery required personnel with specialized knowledge on TV service and telecommunication network, reliable iTV delivery network and proper monitoring systems. The essential information on this service is presented in Table 7.1 and its performance is assessed in Table 7.2. More detailed description on this service can be to Appendix A.2.5.1.

Figure 7.2: Service Model of KPN iTV Management



iTV innovation service

The iTV innovation service (Figure 7.2) was responsible for the development of iTV service that included adding new functionality and improving existing features in iTV products. Driven by market trends, new innovation projects were initiated and carried out by the innovation team. The management team was the customer of this service and received reports on project outcome. Before being implemented in the delivery network, new innovation products needed to be rigorously tested in different environments so that their performance impact on existing services could be minimized. The essential information on this service is presented in Table 7.3 and its performance is assessed in Table 7.4.

iTV maintenance service

The iTV maintenance service (Figure 7.2) was collaboratively provided by the operation team and NOC on continuous daily basis. This service provided monitoring at system and network level and regular maintenance of configurable items. The items that needed to be maintained were added by the innovation service when new products went live. The operation team delivered weekly reports on service performance to the management team. The essential information on this service is presented in Table 7.5 and its performance is assessed in Table 7.6.

iTV incident fixing service

The iTV incident fixing service (Figure 7.2) was also offered by the operation team. The priority in this service was to remove the service impact that was caused by incidents as soon as possible. During the provision of this service, the operation team first analyzed possible root causes to the incident reported. Then, they planed and delivered the fixing activities. Mostly incidents were fixed by workarounds at the moment while structural solutions usually came later. The essential information on this service is presented in Table 7.7 and its performance is assessed in Table 7.8.

iTV problem management service

The iTV problem management service (Figure 7.2) took care of both technical and non-technical issues in iTV services. These problems were identified from incidents or issues that could potentially influence iTV service performance. For technical problems, the solutions were implemented by the operation team. Certain problem solutions might require the innovation team to delivery a new release. The essential information on this service is presented in Table 7.9 and its performance is assessed in Table 7.10.

Table 7.1: Essential Information on the iTV Service

Modeling Component	Descriptions
Service	The KPN iTV service
Customer	End users
Provider	The iTV service management team (KPN NetCo FO TV&Media)
Production	iTV products
Technical capacity	The iTV delivery network, the monitoring systems
Personnel capacity	Employee workload, iTV expertise

Table 7.2: Performance Assessment of the iTV Service

Assessment Criteria	Descriptions
Customer involvement	The customers received the iTV service and reported incidents regarding service impact their experienced.
Participant interaction	The iTV service management team provided the iTV service by managing the innovations, operations and problems.
Human operation involvement	Managing and assuring the performance of iTV service
Software service involvement	The iTV delivery network and monitoring systems
Granularity	From a customer's perspective: low, the customers only received the iTV service and did not see the operations behind the service provisioning. From a the provider's perspective: high, the iTV service performance relied on the performance of iTV innovation service, iTV maintenance service, iTV incident fixing service and iTV problem management service.
Dependency	The provision of iTV service relied on a joint effort of the innovation, the operations and the problem management.

7.1.3 Performance component generation

Having the essential information on iTV service and its four component services presented in the previous section, the performance indicators of these services were generated by applying the four service performance component proposed in the frame-

Table 7.3: Essential Information on the iTV Innovation Service

Modeling Component	Descriptions
Service	The iTV innovation service
Customer	The iTV service management team
Provider	The iTV innovation team
Production	Innovations of iTV service
Technical capacity	The iTV delivery network, development and testing environment
Personnel capacity	Employee workload, iTV innovation expertise

Table 7.4: Performance Assessment of the iTV Innovation Service

Assessment Criteria	Descriptions
Customer involvement	The customers received new innovations of iTV service.
Participant interaction	The iTV innovation team, driven by new business wish from markets, carried out innovation projects and implemented changes to improve the functionality and quality of iTV service. The iTV service management team received new innovations of iTV service.
Human operation involvement	Innovation project management
Software service involvement	The iTV delivery network, development and testing environment
Granularity	From a the customer's perspective: low, the customer only received the produced innovation products of iTV service and was not involved in the development process. From a the provider's perspective: high, the provider initiated innovation projects that went through the product life cycle of design, development, test and implementation.
Dependency	The innovation service was driven by the trends in TV markets. The outcome of innovation service was perceived by the customers of iTV service and was directly in relation to the operation service.

Table 7.5: Essential Information on the iTV Maintenance Service

Modeling Component	Descriptions
Service	The iTV maintenance service
Customer	The iTV service management team
Provider	The iTV operation team, NOC
Production	Daily monitoring and regular maintenance of iTV service
Technical capacity	The iTV delivery network, the monitoring systems
Personnel capacity	Employee workload, iTV operation expertise

Table 7.6: Performance Assessment of the iTV Maintenance Service

Assessment Criteria	Descriptions
Customer involvement	The customers received daily operation, regular maintenance of iTV service.
Participant interaction	The iTV operation maintained the iTV service via daily operations and regular maintenance releases.
Human operation involvement	Daily operations and maintenance of iTV service
Software service involvement	The iTV delivery network, monitoring systems
Granularity	From a the customer's perspective: low, the customers were informed about the performance of iTV service on regular basis. From a the provider's perspective: high, the operation service included the daily operations and regular maintenance.
Dependency	The maintenance service received new configurable items from the innovation service and requested new maintenance release to the innovation service. It provided monitoring at system level while NOC provided the network monitoring.

work.

The performance indicators of **iTV service** are listed in Tabel 7.11. The interac-

Table 7.7: Essential Information on the iTV Incident Fixing Service

Modeling Component	Descriptions
Service	The iTV incident fixing service
Customer	The iTV service management team
Provider	The iTV operation team
Production	Fixings of iTV service incidents
Technical capacity	The iTV delivery network, the monitoring systems
Personnel capacity	Employee workload, iTV operation expertise

Table 7.8: Performance Assessment of the iTV Incident Fixing Service

Assessment Criteria	Descriptions
Customer involvement	The customers received fixings of iTV service incidents.
Participant interaction	The iTV operation maintained the iTV services via daily operation and incident fixing.
Human operation involvement	Incident analysis and fixing plannings
Software service involvement	The iTV delivery network, monitoring systems, incident ticketing systems
Granularity	From a the customer's perspective: low, the customers were informed about the service impact and fixings during incidents. From a the provider's perspective: high, it included the incident root cause analysis, fixing activity planning and execution.
Dependency	The incident fixing service received incident tickets from NOC. Regarding the fixing plans, the incidents that fixed by workarounds might be identified as problems and requested structural solutions from the problem management service.

tion bottleneck technically depended on the stability of iTV delivery network and the operational priority played an important role in allocating capacity. The customer satisfaction was mainly measured by customer call ratio on daily or weekly basis and by

Table 7.9: Essential Information on the iTV Problem Management Service

Modeling Component	Descriptions
Service	The iTV problem resolution service
Customer	The iTV service management team
Provider	The iTV problem management team
Production	Bug fixings and structural solutions to iTV service
Technical capacity	The iTV delivery network, the monitoring systems
Personnel capacity	Employee workload, iTV problem management expertise

the net promoter score on quarterly basis. In order to ensure service delivery, personnel capacity was assigned by the service management team and the delivery network and the monitoring systems at different levels were required as the technical capacity.

The performance indicators of **iTV innovation service** were listed in Table 7.12. This service contained a development cycle of IT development. The level of requirement traceability indicated the level of transparency in the development. Traceable requirements were helpful guidelines to ensure a smooth development cycle. The capacity planning in the innovation service was determined by the workload and time planning. Project delay and additional changes of requirements would have influence on the capacity allocation. The service management team was the customer of the innovation service and evaluated the innovation products delivered by checking the delivery time, cost and the product quality. The personnel capacity could be measured by the supplier competence, the available capacity in the innovation team and the communication effectiveness between the innovation team and suppliers. The development was only possible if there was proper development and testing environment.

The performance indicators of **iTV maintenance service** were listed in Table 7.13. The performance of this service was highly influenced by the monitoring coverage of the configuration items in iTV service. An effective delivery of maintenance service depended on the availability of new configuration items and the monitoring coverage at different levels. The availability of new configuration items relied on an effective communication between the innovation team and the operation team, because these new items came from the innovation service. Monitoring systems were required at the system, the platform and the network level. The personnel capacity was in relation

Table 7.10: Performance Assessment of the iTV Problem Management Service

Assessment Criteria	Descriptions
Customer involvement	The customers received the implemented structural solutions to identified problems.
Participant interaction	The iTV problem management identified and handled all kinds of problems in iTV services, both technically and non-technically.
Human operation involvement	Problem identification and solution proposition
Software service involvement	The iTV delivery network
Granularity	From a the customer's perspective: low, the customers only checked the progress of problems resolutions but were not involved in the solution implementation. From a the provider's perspective: medium, the problem management service provider needed to investigate, design, and implement the solutions.
Dependency	The problem resolution service worked closely with the maintenance service and the incident fixing service and updated each other about the latest status of problems, the structural solutions implemented, and possible correlations between problems and incidents. For certain problem solutions, it was also possible to initiate new releases that required the innovation service to do the delivery.

to the available maintenance capacity and the communication effectiveness within the operation team. It was because that some maintenance capacity might be be shifted to incident fixing due to the priority in service operations.

The performance of **iTV incident fixing service** (Table 7.14) was directly in relation to the service impact that was perceived by customers. The customer satisfaction was reflected in customer calls and was determined by the delay of incident fixing. The bottleneck in speeding up the incident fixing service was due to operation team's knowledge on incident root causes. The capacity allocation was determined by the estimation of the service impact and the priority in the operation team. The personnel capacity was dependent on the available capacity in the incident fixing team and their level of expertise. The technical capacity required in restoring services included

Table 7.11: Performance Components of the iTV Service

Performance Components	**Performance Indicators**
Network bottleneck / capacity allocation	- stability of iTV delivery network - operational priority
Customer Satisfaction	- customer call ratio - net promoter score
Personnel Capacity	- available service management capacity
Technical Capacity	- availability of iTV delivery network - monitoring at system, platform and network level

Table 7.12: Performance Components of the iTV Innovation Service

Performance Components	**Performance Indicators**
Network bottleneck / capacity allocation	- traceability of requirements - project delay - number of additional changes
Customer Satisfaction	- on time delivery - accurate cost estimation - good product quality
Personnel Capacity	- supplier competence - available innovation capacity - communication effectiveness between iTV innovation team and suppliers
Technical Capacity	- development and testing environment

the monitoring systems at multiple levels, the iTV delivery network and the testing environment for fixing solutions.

Differing from iTV incident fixing service, the time issue was slightly less critical in **iTV problem management service**. The performance of this service (Table 7.15) was mostly associated with the total number of problems. The knowledge on problem root causes determined the bottleneck in finding solutions, while both personnel and technical capacity allocation was influenced by the operational priority. The personnel capacity included the available capacity at problem management and their level of expertise. The technical capacity included the delivery network and monitoring systems at multiple levels.

Table 7.13: Performance Components of the iTV Maintenance Service

Performance Components	Performance Indicators
Network bottleneck / capacity allocation	- availability of new configuration items - level of monitoring coverage at system, platform and network level - operational priority
Customer Satisfaction	- service availability
Personnel Capacity	- available maintenance capacity - communication effectiveness within operation team
Technical Capacity	- monitoring systems at system, platform and network level

Table 7.14: Performance Components of the iTV Incident Fixing Service

Performance Components	Performance Indicators
Network bottleneck / capacity allocation	- iTV operation team's knowledge on incident root cause - estimation of service impact - operational priority
Customer Satisfaction	- customer call ratio - incident fixing time
Personnel Capacity	- available incident fixing capacity - level of expertise
Technical Capacity	- monitoring systems at system, platform and network level - iTV delivery network - testing environment

7.2 Therapeutic phase

In this case study, the operational challenge was to cope with the increasing pressure from handling iTV incidents meanwhile ensuring the performance and innovativeness of iTV service at a satisfactory level. Having all the essential information generated from raw case material in the previous diagnostic phase, a few performance issues were found in the iTV SSC. In the therapeutic phase, these issues will be introduced

Table 7.15: Performance Components of the iTV Problem Resolution Service

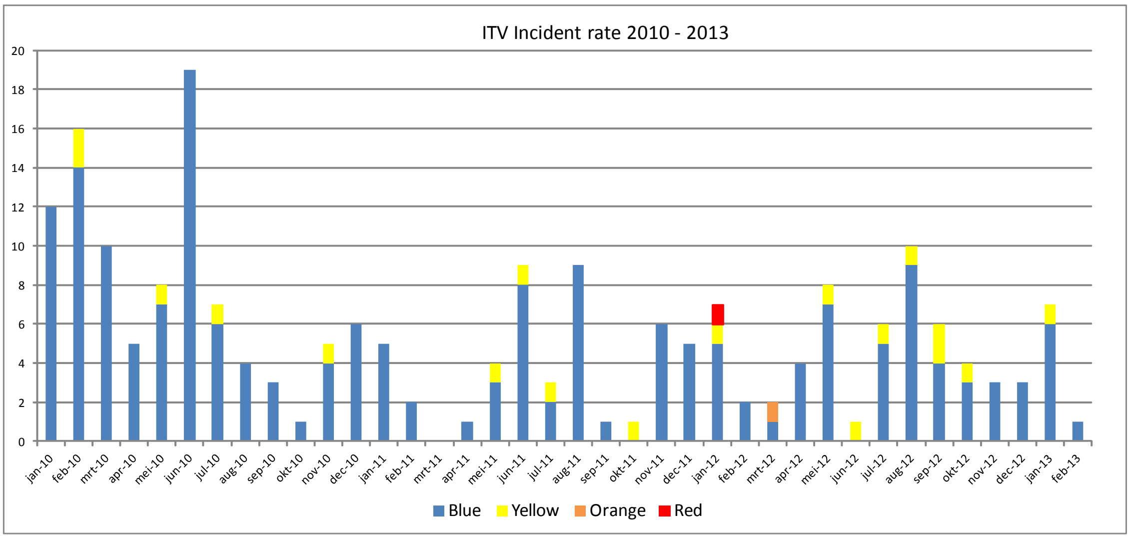
Performance Components	Performance Indicators
Network bottleneck / capacity allocation	- iTV problem management team's knowledge on problem root cause - operational priority
Customer Satisfaction	- number of problems
Personnel Capacity	- available problem management capacity - level of expertise
Technical Capacity	- iTV delivery network - monitoring systems at system, platform and network level

first (section 7.2.1), then detailed performance analysis will be provided by applying causal analysis and system dynamics modeling (section 7.2.2).

7.2.1 Performance issues

As already mentioned at the beginning this case study (section 7.1.1), the iTV operation team suffered the pressure from handling continuous severe incidents during the period of 2010 - 2013 (Figure 7.3), and the iTV management team could not come up with any effective solution to improve this situation. This operational pressure resulted from the following three issues.

Figure 7.3: iTV Incident Arrival Rate during 2010 - 2013



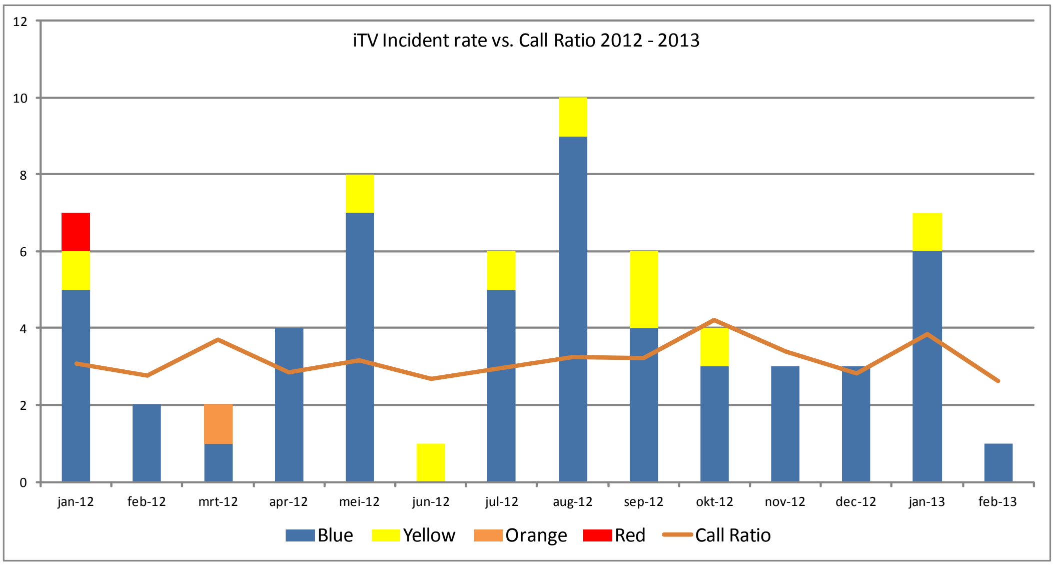
High incident arrival rate

The success of iTV service incentivized continuous innovation and brought too much demands on service operations that the operation team could not cope properly. The high incident arrival rate kept the operation in an intense situation and the service quality and reputation was impacted.

Figure 7.3 depicted the incidents reported at iTV service during 2010 - 2013. From 2010 to Q1 2011, the high amount of incidents didn't all turn into serious ones because of the comparably small installed base at customer side. Thus most of the incident occurred during this period were code blue. From Q2 2011 onwards, more severe incidents with code yellow, orange, and even red were reported.

Customer call ratio was the most direct indicator to service performance. According to the available data of call ratio and incident rates (Figure 7.4), there were constantly severe incidents during the period of 2012 - 2013 whilst the call ratio was kept at a high level. After a series of code yellow incidents, the call ratio reached its peak in October 2012.

Figure 7.4: iTV Incident Rate vs. Call Ratio 2012 - 2013



Various incidents

The technological complexity of iTV service was already mentioned briefly in the introduction of its delivery network (Appendix A.2.5.1). The incidents could be triggered by errors or problems found in multiple places in the iTV delivery network. For instance, some root causes came from the set-top box software, the VOD application in the platform, the router in the ISP infrastructure or the HD sender problem in the BSC/Content. The iTV operation team were required to hold a wide range of working scope, to have very deep and detailed knowledge of the delivery network.

Limited operational resource in incident fixing

Time pressure was a huge issue for the iTV operation team during the incident fixing process. The service impacted needed to be restored as soon as possible, especially when the incident happened to a large customer base. Sometimes the service restoration had to be done with a small patch of customers as a trial before it could be further implemented with a bigger patch. With a large customer base impacted, the operational team needed to perform several repetitive fixings in different customer patch in order to fully restore the service.

Given complexity in the delivery network (Appendix A.2.5.1), experts with end-to-end knowledge of the iTV service was highly needed but was a scarce resource. There were only a few people at the iTV operation team who had knowledge about the entire network. If incidents were reported continuously, the iTV operation team often faced a shortage of available operational resource to carry out the fixing activities.

7.2.2 Performance analysis

With the performance issues at iTV service management clarified, the analysis began with constructing causal diagrams by applying the proposed four-step causal analysis approach. After revealing the causal loops in iTV SSC, more performance issues came to light and some managerial tradeoffs were identified. A system dynamics model was built to experiment different service management policies with respect to the managerial tradeoffs. At the end, the analysis was concluded with the identification of the performance gap and the proposition of solutions.

iTV service causal analysis

Operational resources should be planned properly before the occurrence of potential incidents and should not be trapped into 'fire fighting' [82]. In order to relieve the pressure at iTV operation from handling continuous incidents, decisions on operational planning at iTV service management needed to be assessed in relation with the performance of iTV service.

Regarding the service management structure at iTV (Figure 7.2), four services, viz. the incident fixing service, the problem management service, the maintenance service and the innovation service, needed to be managed. The managerial decisions should be made to facilitate these services and to achieve optimal service performance.

The following analysis was conducted according to the proposed four-step causal analysis approach (in Figure 4.5, section 4.4.2) includes identifying KPI list for each service operation, constructing causal loops within one or more focal operations, extending relevant KPIs in the built causal loops, and creating causal links among service operations.

Step one: service operation KPIs

All the KPIs for operating the services at iTV service management were already identified in section 7.1.3. However **according to the guideline that was suggested in section 4.4.2, sometimes additional KPIs needed to be discovered in order to reveal hidden causal links**. Therefore, **two model-building workshops were conducted to collect the most important performance issues at iTV service management**. iTV managers who were responsible for the above mentioned services participated the workshops. All the performance issues modeled in the following causal diagrams were suggested by these participants. The workshop participant list can be found in Appendix A.4.7. As a result, the causal analysis for each iTV service operation is presented in the next step.

Step two: causal loops in iTV service management

The following causal loops were made separately from the perspectives of operating the four services.

Incident fixing service

The number one rule in iTV incident fixing was to remove the service impact perceived by customers as soon as possible. Customer call ratio was the most direct indicator for measuring service impact. Solution parties were the ones who were responsible for taking away the service impact and performed the fixing activities. Figure 7.5 depicts the key issues in incident fixing among which two causal loops were created.

Quick fixing-service impact loop

Incidents that caused service impact at customers were reported from the technical help desk (THD) to NOC, when there was an significant increase in customer call ratio. Better monitoring at system level could reduce the signaling sent from THD to NOC, and also reduce customer call ratio. If the impact on service was continuously perceived, both internal signaling and customer call ratio increased.

The increasing signaling from THD to NOC urged the solution parties to fix incidents. Given the time pressure on incident fixing, the solution parties often needed to provide temporary solutions (workarounds) to take the impact away quickly. Listening to experts more and giving more responsibility to experts would determine the problem domain sooner and inform the solution party quicker.

Quick fixing-incident loop

Although workarounds could remove service impact quickly, they also added more temporary solutions to the platform. More temporary solutions increased the complexity in platform maintenance, because there was no time for sufficient impact testing and nor time to check the fitness of these temporary solutions in the platform. This would further raise risks and make the network unstable. As a result, new incidents might occur.

Problem management service

A structural solution loop was presented in Figure 7.6. Problem management focused on removing the root causes of incidents structurally. It aimed to provide fundamental solutions to problematic issues that were either identified from existing incidents or could lead to potential incidents.

Focusing on incident root cause encouraged to find fundamental solutions and would reduce the number of potential incidents. Once a quick fixing solution was available, the impact on service was taken away by implementing workarounds successfully. The elimination of service impact called for the closure of Be-Alert process and dismissed the attention to finding incident root causes and structural solutions. Therefore having quick fixing solutions would slow down the finding of fundamental solutions.

Maintenance service

Active monitoring in maintenance (Figure 7.7) provided more early internal signaling on incidents and might even prevents potential incidents. Active monitoring required the availability of monitoring items, a good monitoring protocol and an effective threshold indication. Monitoring should be looked at in a good way and at least included the common items. The difficulties in having monitoring items available came from the innovation projects and the instability of network. The network was likely to become unstable if the platform became too complex to be maintained.

As already seen in the quick fixing-incident loop in Figure 7.5, more quick fixing solutions implemented in the platform increased the complexity in maintenance, and further led to higher instability of network. In order to reduce the instability of network, more maintenance releases were needed.

Innovation service

Innovations are driven by customer demands [183]. Both the innovation team and operation team at iTV aimed to provide satisfactory services to customers. However the correlations between innovations and operations were twofold. On one hand, innovations upgraded service functionality and brought fundamental solutions to existing service flaws. On the other hand, due to high demands on innovations it brought new services that challenged testing and monitoring. In the Figure 7.8 diagram, these correlations were explained in two causal loops respectively.

Innovation-incident loop

High demands on innovations put more pressure on testing and monitoring. The testing of a new service or product needed to be done in different testing environments and might require re-work before went live. The pressure of catching deadlines sometimes made people to follow testing rules less strictly. In addition, when there were many innovation projects in the pipeline, it did not leave sufficient time for testing. Insufficient testing led to potential incidents.

As already mentioned in the active monitoring-incident loop (Figure 7.7), active monitoring could prevents potential incidents. New monitoring items added by new services or products needed to be known by operations. However the availability of new monitoring items could not be guaranteed timeously, therefore not all of them could be properly monitored.

Solution-focused innovation loop

Service impact increased the number of customer calls and decreased the customer satisfaction. If the net promoter score (NPS) went down, it implied that the service was losing customers. A shrinking customer base led to less customer demand in the market. However, the decrease in NPS stimulated the service provider to demand more innovations in their services and products in order to gain customers back.

Driven by customer demand, more innovations were initiated to improve services and products. Fundamental solutions were provided to eliminate the bugs and flaws and to reduce the possibility of having potential incidents. If there were less incidents reported, less impact on service would be perceived by customers. Thus the number of customer calls would be reduced and the NPS would go up again.

The causal analysis made above revealed the insights into performance issues in managing the four services at iTV. It was worth noting that a few Performance indicators were modeled in more than one causal diagram above and connected the performance of different services. Theses indicators included the potential incidents, the quick fixing solution, the available monitoring items and so on.

In the next step, the scope of causal analysis was extended across the four services by linking these indicators and practical implications for iTV management were generated. Please note that **the next step conducted in this case study was the combination of step three and four in the proposed four-step approach** (in Figure 4.5, section 4.4.2) in causal analysis.

Step three: causal connections among iTV services

In this step, the performance indicators that were modeled in more than one causal diagram were chosen and structured in a new diagram. In this new di-

Figure 7.5: Causal Diagram of Incident fixing

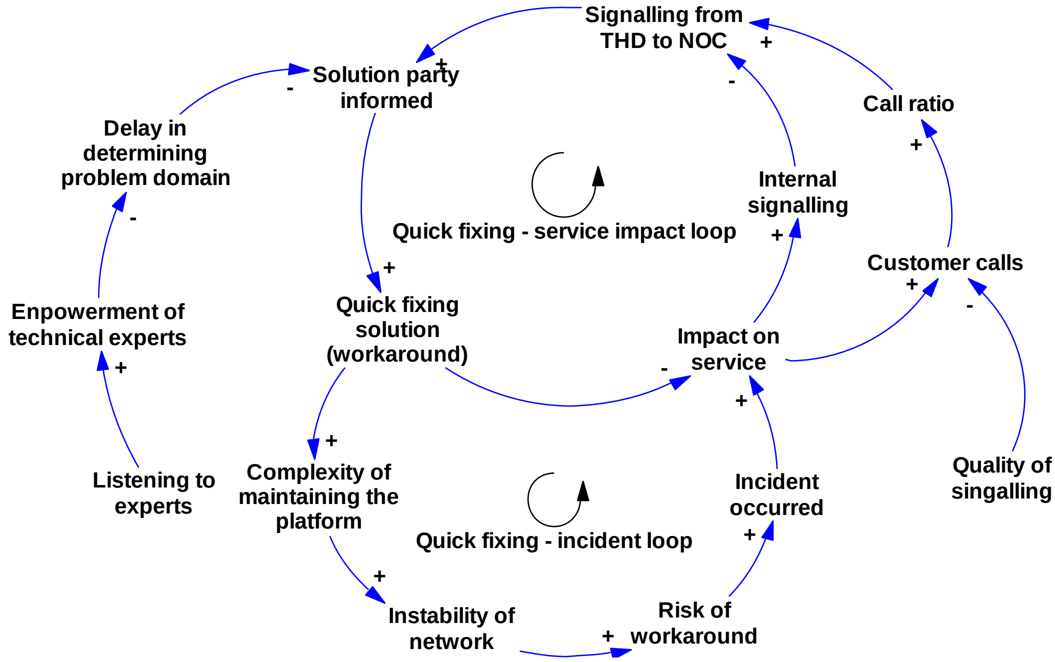
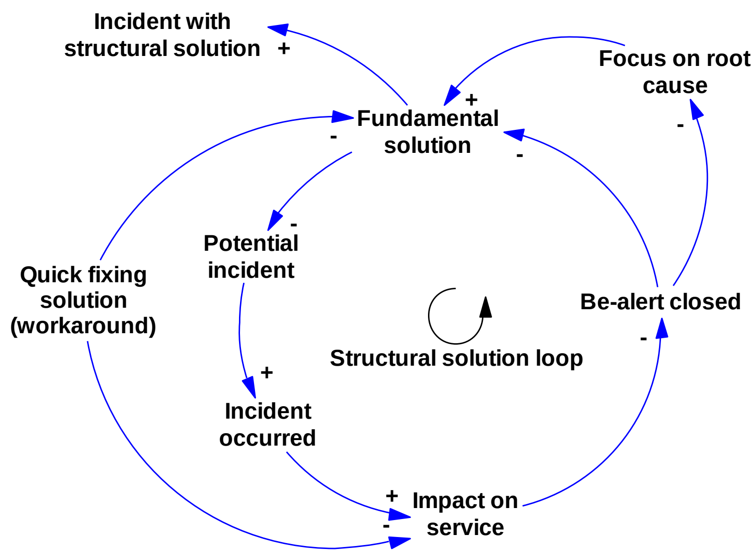


Figure 7.6: Causal Diagram of Problem Resolution



agram (Figure 7.9), the performance of the four services were connected via the links among the chosen indicators.

The indicators 'bugs' and 'potential incidents' were modeled as additional bridges among the four services. Both innovation and quick fixing solution could initiate changes. Changes were not flawless and might contain bugs. The increase of bugs also increased the risk of having potential incidents. Proactive monitoring detected service performance anomalies timeously and therefore reduced the

Figure 7.7: Causal Diagram of Maintenance

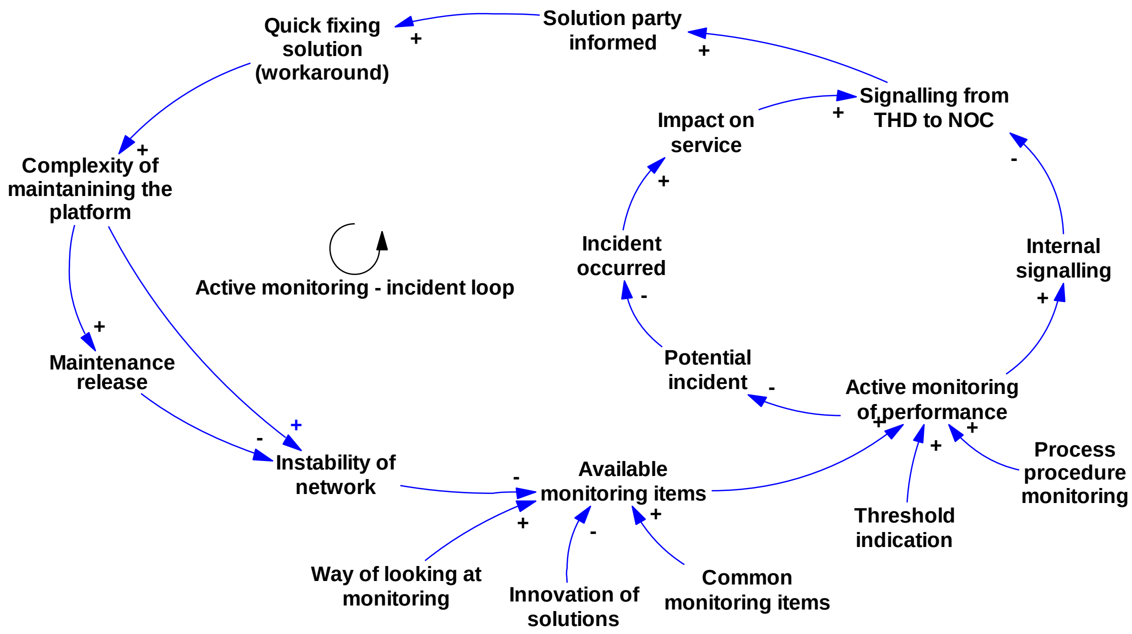
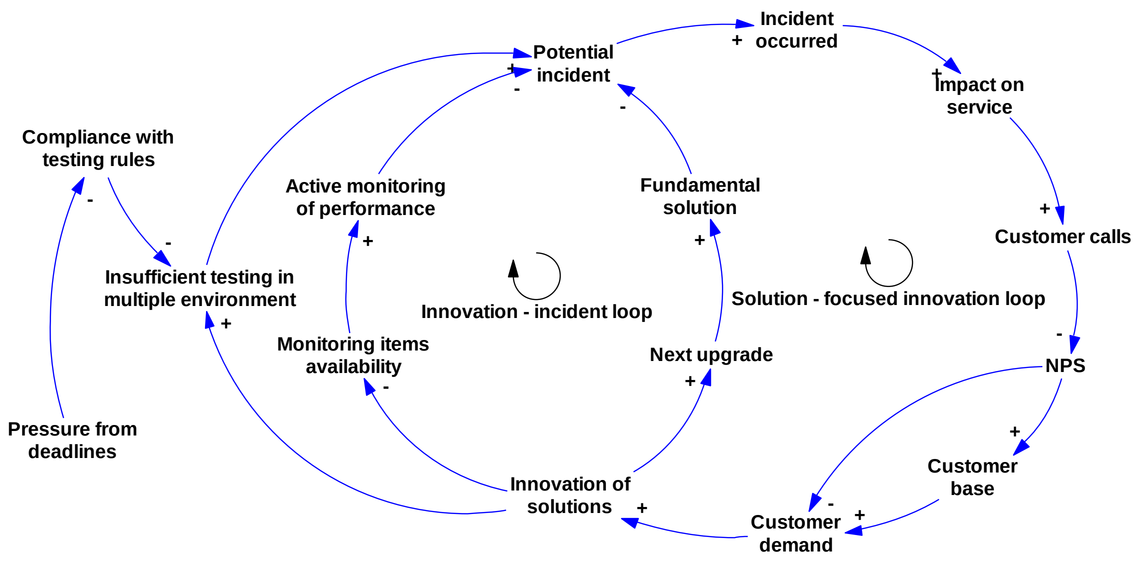


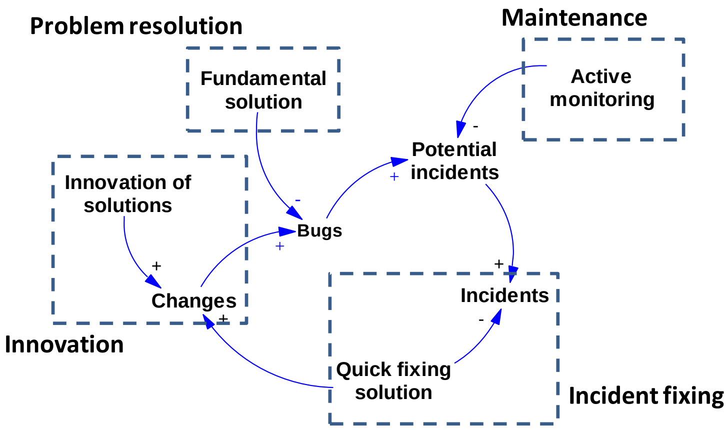
Figure 7.8: Causal Diagram of Innovation



number of potential incidents. Quick fixing solution could reduce the number of incidents by performing workarounds but had nothing to do with the bugs. Only fundamental solutions could structurally remove the bugs.

With all the analysis conducted above, great insights into the service management of iTV services was obtained and could provide sufficient knowledge on exploring solutions to the problem at iTV service management. In the next step, the analysis further deepened the causal analysis between the innovation, operations and the problem management. Please note that **the causal diagrams that**

Figure 7.9: Causal connections among iTV services



were created in the next step resulted from repeating step two and three in the proposed four-step approach (in Figure 4.5, section 4.4.2).

Step four: managerial tradeoffs

As mentioned at the beginning of the iTV service causal analysis, decisions on operational resource planning at iTV service management needed to be assessed in relation to the performance of iTV service.

Many managerial tradeoffs had to be made between having innovativeness and reliability of iTV service. In principle, the innovation team tried to bring more innovation to iTV service; the problem management team was responsible for the quality assurance (QA) of iTV service; the operation team handled all iTV incidents. The following causal loops introduced and explained the most typical tradeoffs in iTV service management. The analysis was made with the premise that there was a fixed total personnel capacity of innovation, operation and problem management, and the capacity allocation was only possible by transferring capacity among these three teams.

The rework cycle (Figure 7.10)

The causally linked service operations formed up a rework cycle [184], in which the 'undiscovered rework' in innovation led to more downstream work in QA bug fixing and operational control in incident fixing. High workload innovation would lead to more (un)discovered bugs. More bugs required more QA capacity and the workload QA increased. The same effect of high workload was also found between QA and incident management. High workload QA led to high bug activation rate and more incidents occurred. Thus more capacity was required in incident management.

High workload resulted from high capacity requirement and low available staff. In order to avoid burn out from high workload, more staffs were needed. However, staffs could only be transferred among the three capacity pools, namely innovation staff, QA staff and operation staff. If more staffs needed to be allocated to incident management, it took staffs from QA and workload QA increased. If more staffs needed to be allocated to QA to relieve high workload QA, it decreased the available staffs at innovation and left the workload innovation high. As described earlier, high workload led to more work downstream.

Goal-seeking process (Figure 7.11)

In this goal-seeking process, the tradeoff was to allocate capacity between innovation and QA bug fixing. When the target innovativeness increased, more innovation work was planned in pipeline. With an increasing completion rate of innovation work, higher bug occurrence rate could be expected. Capacity was on demand in innovation work and QA bug fixing, when they both increased.

If more staffs were transferred to QA for bug fixing, there were less available staffs left in innovation work. Subsequently, losing innovation staff would lead to high innovation workload. High workload made people work under pressure or in short of capacity and might influence the quality of work. Low quality of work would leave more bugs per innovation work. If putting more staffs at innovation, on one hand it would have better chance to reduce bug occurrence per innovation work by reducing innovation workload. On the other hand, more innovation work would be completed and the total bugs from innovation work in general would increase.

Capability trap (Figure 7.12)

The capacity trap [82] could have already been seen from the previous two feedback loops. Here it focused on the capacity trap between incident management and QA, where allocating more capacity in handling incidents would drain the QA capacity.

When incidents occurred continuously, more capacity was required in incident management and the incident workload increased. The growth of incident workload demanded more operation staffs. In order to balance the workload in incidents fixing, more capacity needed to be allocated into incident management. The change in operation staffs initiated transferring staffs from QA. The causal link between the QA staff and the incident occurred was better explained in Figure 7.10. The decrease in QA staff led to an increase of QA workload. High QA workload led to more effect on having potential incidents. Once this effect reached certain level, more bugs was activated and eventually more incidents occurred. Thus this reinforced the capacity trap between incident management and QA.

Figure 7.10: The rework cycle: higher workload leads to more work downstream, downstream amplification process

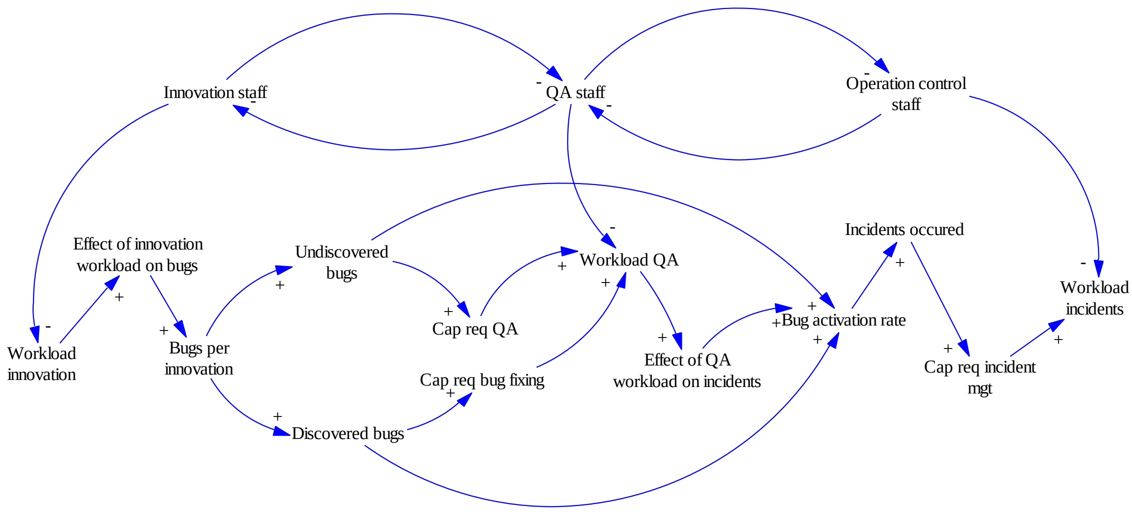
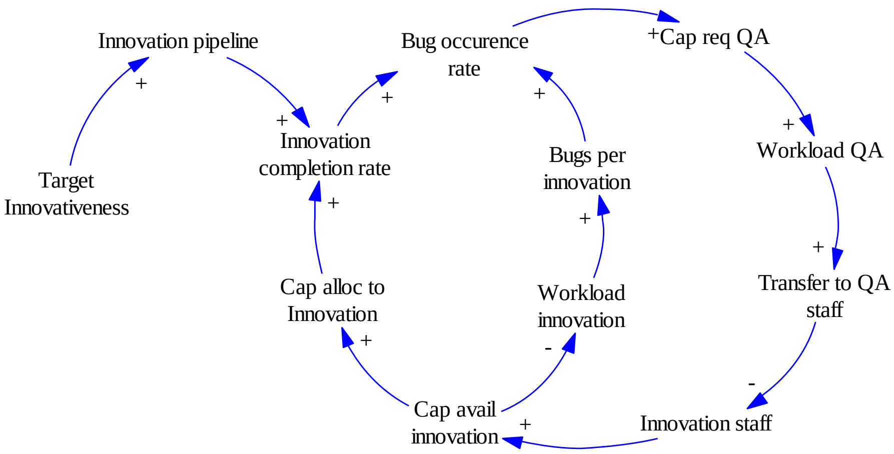


Figure 7.11: Goal-seeking processes: target innovativeness, workload management

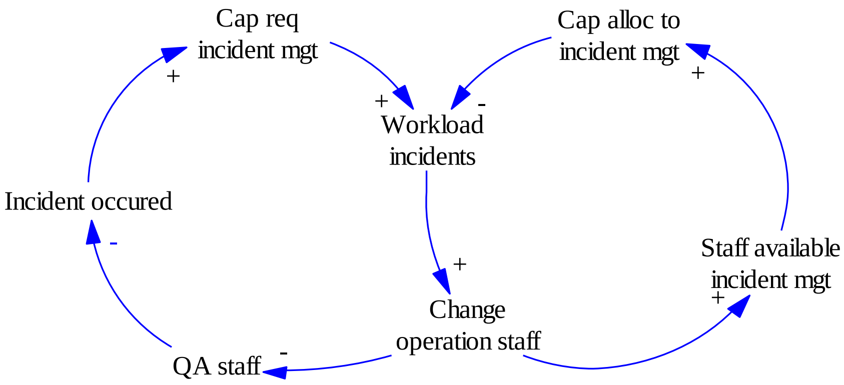


Thus far the iTV service causal analysis was completed and the managerial tradeoffs in service management were analyzed. On the basis of them, a system dynamics model was built to test different scenarios of service management policies.

Simulation modeling of iTV service

In this section, a system dynamics model of managerial tradeoffs at iTV service management was built based on the causal analysis presented above. Given the space

Figure 7.12: Capability trap: incident handling drains QA



limitation, only two service operation policies were presented: the counterproductive policy (S01) and the temporarily effective policy (S02).

S01 No more pooling with QA staff

In the present work system, staffs dealing with improving the quality of the existing infrastructure were pooled together with staff dealing with incidents. As a result, the QA staff increased in size (Figure 7.13, 3rd row, middle graph) in response to the increased flow of new functionality and this helped to keep the number bugs down for a considerable period of time (Figure 7.13, 2nd row middle graph). However, if management maintained a clear distinction between these two types of staff, performance even deteriorated sooner. Without pooling between these two types of staff, incidents went through the roof (Figure 7.13, 2nd row, right graph).

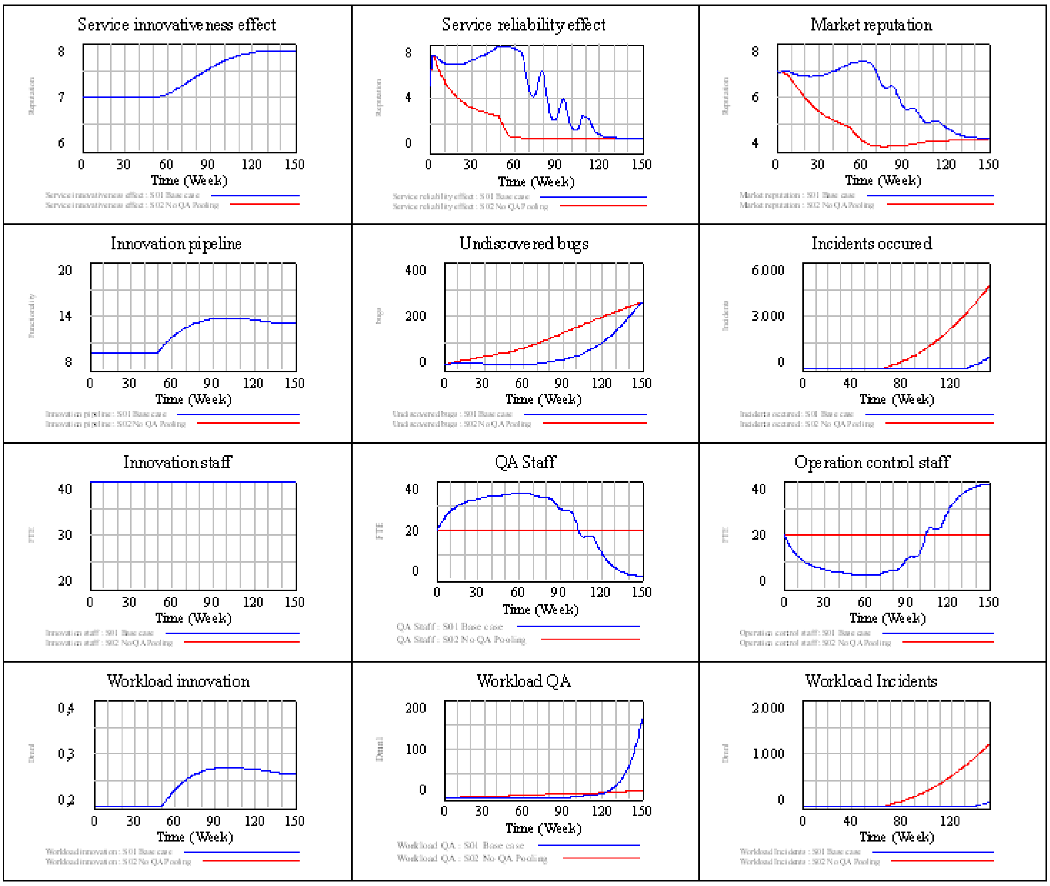
S02 Increasing active monitoring (condition-based maintenance)

A major trend in the world of maintenance & reliability is the condition-based maintenance (CBM), which runs active and continuous monitoring of system performance in order to spot any potential incident-in-making timely enough to make sure that incidents never happen [185]. As the sensitivity analysis in Figure 7.14 showed, this could be a high-leverage policy, but only if this active monitoring was vastly more effective than in the base case.

The crux in this scenario was not the direct effect of how many incidents-in-the-making were prevented timeously, but rather the indirect effect that more effective active monitoring led to fewer incidents to be managed, which led to a lower demand on incident management staff, which led to more staff available for QA, which led to fewer bugs, which led to a lower inflow of new incidents. This was emphasized once more in Figure 7.15 (identical to the middle graph in the 2nd row of Figure 7.14 .

At levels of around 9 times the base case level of CBM effectiveness, active monitoring indirectly led to an almost steady level of undiscovered bugs. Thus, this policy could be structurally effective but required a serious & successful investment in active monitoring.

Figure 7.13: System performance in Scenario S01 No QA Pooling



Performance assessment by simulation

Having the above analysis done, a gap in managing iTV services came to light. It was clear that any change brought by innovations had potential, direct or indirect impact on service performance received by customers. The operations teams were under pressure firefighting these incidents, more than half of which were caused by change. Meanwhile the innovation teams kept up the pace of the development, unaware of the resulting performance impact on service performance.

Unfortunately there was no effective learning loop in the management of iTV SSC. The causal analysis revealed the missing performance link (Figure 7.9): a bridge among the four iTV services. Changes brought by either innovation work or quick incident fixings produced bugs, which potentially triggered incidents at the customer side.

Figure 7.14: System performance in S02 with various degrees of active monitoring

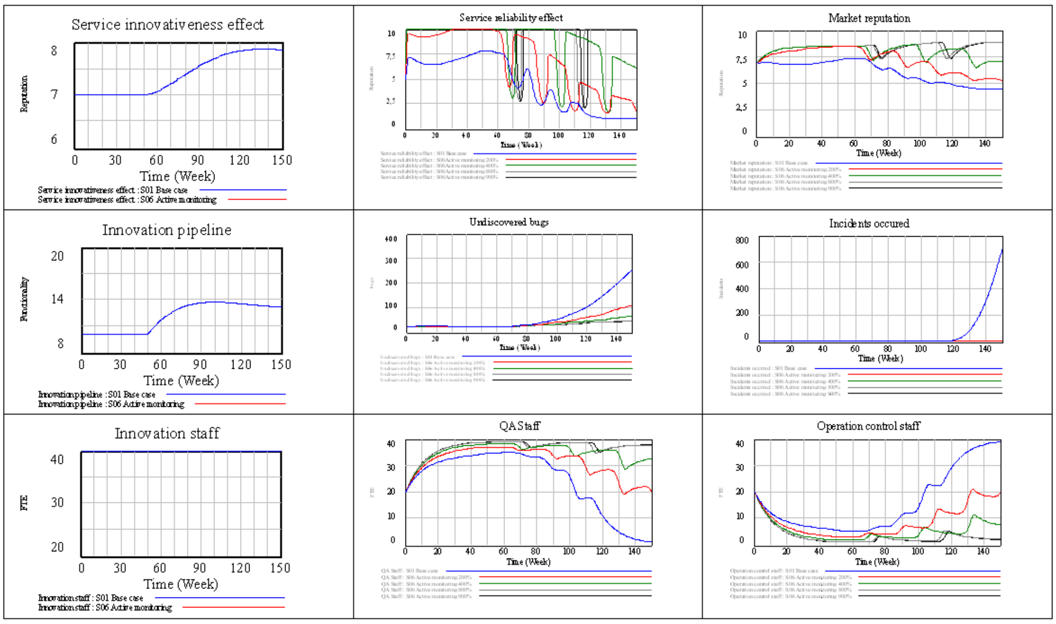
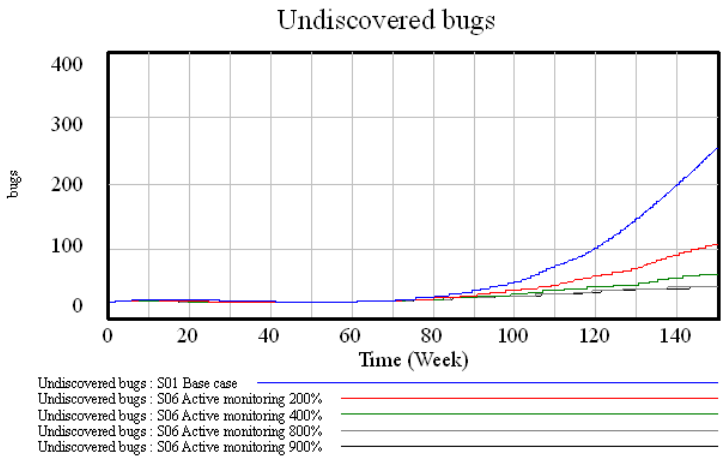


Figure 7.15: The key driver for sustainable success in active monitoring, the number of undiscovered bugs



Fundamental solutions could fix bugs and active monitoring detected and prevented incident manifestations.

Managerial decisions should be made with careful consideration of the tradeoffs regarding operational resource planning. The performance links among iTV services indicated the consequences in capacity allocation. Emphasizing on one part of the SSC might raise the demand of capacity at other parts within the chain. Operational priorities in resource planning needed to be made with the awareness of these consequences.

Two exemplary managerial policies were evaluated in the simulation model built for iTV service. The first managerial focus was paid on the staff allocation between quality assurance and incident fixing. If keeping clear distinction between these two types of staff, the number of incidents went up abruptly due to the increasing number of undiscovered bugs. On the other hand, if setting higher priority in bug fixing and pooling staff from incident fixing into quality assurance, this helped to control the number of bugs and so did the number of occurred incidents within certain period. Therefore for short term, quality assurance should be placed with higher operational priority.

According to the simulation result of the second managerial policy, another operational priority should be given to active monitoring. More active monitoring did not only improve service quality by better preventing incident occurrence, but more importantly, it released more capacity from incident fixing which could became available for quality assurance. Thus this gave a long term effect on managing innovations and operations by keeping the number of bugs at a steady level. The other side of this policy was that it required serious investment in monitoring.

7.2.3 Conclusion

The analytics performed in this section was a successful application of the therapeutic phase of the service network diagnostic framework designed. The four-step causal analysis approach provided clear guidance in constructing causal links among iTV services and exploring managerial tradeoffs. The simulation model was built based on those tradeoffs. The simulation results provided opportunities for the iTV service management team to build up learning loops in the iTV SSC and to make effective decisions on resource planning.

Regarding the operational challenge in iTV SSC, the main outcome of applying the performance analytics included two service policies with different time horizons. For short term, more operational resource should be made available for quality assurance, so that the number of bugs and incident occurrence could be kept in control within certain period. In order to structurally bridge the gap, it was advised to have serious investment in active monitoring. This was the optimal way to release operational resource from firefighting and to reach balanced management of innovations and operations.

7.3 Summary

The outcome of this case study discovers the performance gap that lies between managerial decisions and operational performance in the iTV SSC. This section summarizes the answers to the research questions raised at the beginning of this chapter.

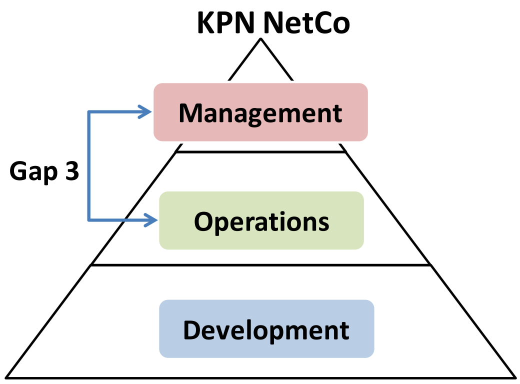
7.3.1 The service management gap

The last case focuses on how managerial decisions and operational performance should be 'bridged' in the context of the innovation-driven iTV service. This performance gap results from insufficient insights and lack of a learning loop in managing iTV services.

The insights into the four iTV services were generated and structured. All key performance issues of iTV service were linked across managing different iTV services and a holistic causal diagram of the management was made. Managerial tradeoffs in resource planing for the iTV management team became clear after the causal analysis.

The built simulation model helped to test service policies to bridge the performance gap, with respect to different operational priorities. For iTV management team, both service innovativeness and reliability should be taken into care consideration. In theory, putting more resource on firefighting the incidents can only further get operational capacity trapped [82], whilst the simulation result also proves that. For short term, putting more efforts in quality assurance would keep the number of bugs and incident occurrence within control. For long term, preventive maintenance could structurally reduce the occurrence of incident but demanded serious investment.

Figure 7.16: The Performance Gap Found in Case Three



The discovery of the service management gap is made possible on the basis of comprehensive and accurate case study and modeling. Research questions 4.1. is answered by the identification of this gap.

7.3.2 Gap formalism

Any change brought about by innovations has potential impact on service performance. The operations teams are under pressure firefighting incidents, more than half of which are caused by change. Meanwhile the innovation teams keep up the pace of the development, unaware of the resulting impact on performance. There needs to be an effective managerial mechanism to facilitate resource allocation and learning loops in IT-enabled SSC. This implies that the management team needs to have a hold of the dynamics of the entire supply chain, understanding the operational resource status and setting proper operational priorities in the chain.

For the management team, leaving operation teams drained of resources would put service performance in risk. The most resource-absorbing activities in IT-enabled SSC, in addition to regular operations and maintenance, are incident fixing and problem solving. Incident fixing, in particular, often drains a huge amount of operational resource very quickly. Since the highest priority in operations is to guarantee a continuous and reliable service provision, the impacted services need to be restored as soon as possible. Problem solving is not as urgent and demanding of resources as incident fixing, but it usually ties up resources for a much longer period.

The chain operational priority is interpreted in terms of operational resource allocation. The decision of chain operational priority should be based on a balanced assessment of innovation and operation performance. This means taking more account of both innovation and operational processes, and the causalities among them, so that the management team can recognize and facilitate the learning loop between these two processes. As mentioned above, incident fixing and problem solving are the two main ways in which resource are absorbed, they should be the main focus when deciding priority in resource allocation.

The service management gap is measured by the available operational resource (denoted by Rava) and the taken operational priorities chain during certain period (denoted by Pops). That is:

$$\boldsymbol{\Gamma}_{\boldsymbol{Managerial}} = (R_{ava}, P_{ops})$$

The available operational resource is determined by the total operational resource (denoted by Rall) and the resource that is required for fixing incidents (denoted by Ri) or solving problems (denoted by Rp). Then:

$$R_{ava} = (R_{all} \cap \neg(R_i \cup R_p)) : R_i \subseteq R_{all} \wedge R_p \subseteq R_{all}$$

The decision of making supply chain priorities is made according to the understanding and assessment of service operation performance, which includes a correct perception of the causal relations among all service operations (including managing innovation activities) (denoted by Cops) and the required operational resource for fixing incidents (denoted by Ri) and solving problems (denoted by Rp).

$$P_{ops} = (C_{ops}, R_i, R_p)$$

The above gap analysis and formalism sufficiently provide positive answers to the research question 4.2.

7.3.3 Bridging attempts

The bridging attempts below conclude the answers to the research question 4.3.

The service management gap is found in the managerial tradeoffs in balancing IT development and services operations. The products delivered by the IT development are not flawless and bring potential risks to service operations. Since the process of service operation is highly automated, the service impact received by customers escalates immediately once an incident occurs. The service management team is under huge pressure in allocating resources and deciding supply chain priorities.

According to its formalism, this gap is measured by the operational resource available in association with the operational priority taken. Having the managerial scope set at supply chain level, the limit of operational resources is twofold. It is not only that the operational resource is in short in fixing incidents and solving problems, but also that the service changes and the associated service impact are not properly acknowledged. For the service management team, it is wise to place balanced service strategy on innovations and reliability. In theory, putting more resource on firefighting can only further get the operations trapped [82], whilst preventive maintenance can structurally reduce incident occurrence but demand serious investment.

Supply chain priorities should be made with purpose to avoid resource trap in service operations. The mentality in managing operations should be changed from being reactive to becoming preventive. For instance, more efforts should be paid on fixing bugs at early stage of development, instead of adding resources in fixing service incidents. In the context of the examined case, problem resolution should be given higher priority in operations, because it has an effect on incident occurrence and service performance in long tern. The bugs hidden in changes would be detected and fixed earlier, which leads to more reliable services and relieves operational resource from getting trapped in fixing incidents.

CHAPTER 8

CONTRIBUTION

The contributions of designing and applying the framework for operational alignment in IT-enabled SSC are presented and discussed in this chapter. First, the insights obtained from the three in-depth case studies contribute greatly to the knowledge base of IT-enabled SSC (section 8.1). Second, this research bridges expertise and methods in information systems and operations management on researching IT-enabled SSC (section 8.2). Last but not the least, this thesis demonstrates how an interdisciplinary research is conducted and provides guidelines to conduct such type of research (section 8.3).

8.1 Contribution to IT-enabled SSC knowledge base

The importance of IT-enabled SSC to today's service economy and our modern daily life is evident. However the operational dynamics in this specific type of SSC has not been well understood. There is a theoretical knowledge gap when it comes to such understanding (Chapter 2.6). The research presented in this thesis examines the operational performance alignment issue and makes a modest contribution towards discovering and bridging operational performance gaps in the IT-enabled SSC in telecommunications industry.

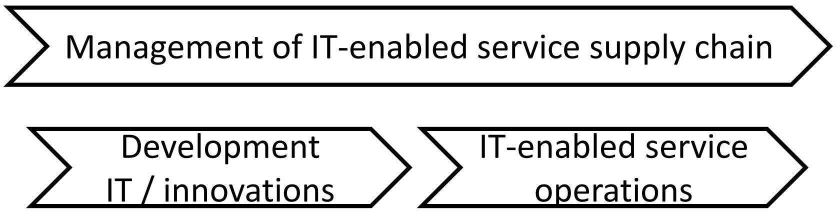
The contents presented in the rest of this section is the answer to the following research question:

Q4.4. What is the added value to the IT-enabled SSC knowledge base?

8.1.1 Complexity of the operational performance in IT-enabled SSC

Being the leading telecommunications and ICT service company, KPN's core business is to provide telecommunication and ICT services that are fully delivered by IT-enabled service operations. Taking a process-oriented perspective, its service supply chain (Figure 8.1) consists of three processes, namely the process of IT development and innovations, the process of IT-enabled service operations, and the process of service supply chain management. This model is viewed as an equivalent process model in comparison with the level 1 process in SCOR model [186].

Figure 8.1: The Process Model of IT-enabled service supply chain



The three in-depth case studies provided fruitful insights into the IT-enabled SSC in Telecommunications. As IT is found in every core service operation in the examined supply chain, business and IT are no longer separately operated and it is hard to distinguish a business-IT gap given the enabling role of IT. Instead, other types of performance gaps are found at different tiers of the IT-enabled service supply chain(Figure 1.6).

Gap one: DevOps gap

The first gap is found between the IT development process and the IT-enabled service operations process. The business owner and IT developer both view the quality of delivered IT products as essential in their own processes. However, a discrepancy between them is found when it comes to IT performance measurement. Although they are both in technical fields, the discrepancy is due to their completely different focuses, processes and priorities. The IT development process focuses on release-based on-time delivery from a project management perspective, in which the IT performance is measured only with reference to the specific piece of IT application delivered in one release. There is no check on the causalities between the releases coming from innovation project meetings. In contrast, in the operations process, measurement of the overall performance of all the IT applications that delivered from innovation projects is required.

The DevOps gap is not new in IT development [179], and several solutions have been proposed to close this gap and ensure continuous delivery [25] [180]. Seamless communication and close cooperation have been recommended to close the DevOps gap. However it is hard to achieve in the IT-enabled SSC researched due to its the large scale and technological complexities.

The IT-enabled service operations process and the IT development process are managed separately in IT-enabled SSC. The connection that bridges the service operations and the IT development starts with requirement engineering in innovation projects. After that it takes a long process of design, building, testing and implementation before the actual IT performance can be measured in service operations. Throughout this communication chain, there are handover points every two steps, where the work in progress is forwarded onto the next step. The testing phase is supposed to provide the final quality control of the built IT applications. However the real performance issues can only be found when the application is finally in use. If there are performance issues found in real operations, new requirements regarding certain issues are proposed in the next release in the development process. The communication chain between development and operations is a long one.

Gap two: service operation gap

The second gap is located within the IT-enabled service operations process in the context of outsourcing. Having all operations enabled by IT applications implies that there is no service available for customers, if any of these IT applications stops functioning properly. The service performance perceived by customers lies in a collective alignment of all the service operations. The challenge in operating such services is twofold. Any malfunction of the IT applications may directly lead to performance impact at customer level. In addition, there is no time window for shutting down the IT applications, whenever any change needs to be made to such services. As a result, very high reliability is demanded of the IT applications.

There are three aspects to facilitating the reliability of IT applications. The first is the technical condition of the IT applications themselves. The more mature the applications are, the more reliable they are. The second consideration is from the administrative perspective. The more complete the administrative process involved in operating these IT applications, the more reliable the applications are. Additionally, monitoring systems provide good indications of the behavior of applications. Therefore the better quality the monitoring systems, the more reliable the IT applications can be.

An outsourcing context for IT-enabled service operations means that these operations are managed separately by different suppliers who may be at different remote locations. Supplier productivity has a strong influence on the service performance delivered, and two aspects can be distinguished, namely supplier competence and supplier management. The first aspect points directly at the level of expertise the supplier holds, which is quite straightforward in its association with productivity.

However the actual supplier productivity that is perceived in service operations depends on how well the operations are managed. Each supplier has clearly defined responsibilities and performance measurements, however it is difficult for any of them to see service performance as a whole from the customer perspective. Managing outsourced IT-enabled service operations requires effective communication amongst all the operations teams so that the performance of each service operation is understood. It is also important to have proper control of the outsourcing situations, to enable smooth collaboration amongst all the suppliers. Service operations should continuously offer reliable services, while customers experience no difference and no impact on quality from the fact that the service operations have been outsourced.

Outsourcing activities in general are influenced by communication, effective knowledge sharing, partnership view, contract details, supplier management [87]. From studying the service operation gap, most of them (e.g. communication, knowledge sharing, supplier management and so on) are found important in operating outsourced IT-enabled services. Additionally, new IT related factors, such as the technical condition, the administration of IT applications and the quality of monitoring systems, are key to the performance of outsourced services.

Gap three: service management gap

The third gap appears in the management of operations and innovations in IT-enabled SSC. Any change brought about by innovations has potential impact on service performance. The operations teams are under pressure firefighting incidents, more than half of which are caused by change. Meanwhile the innovation teams keep up the pace of the development, unaware of the resulting impact on performance. There needs to be an effective managerial mechanism to facilitate resource allocation and learning loops in IT-enabled SSC. This implies that the management team needs to have a hold of the dynamics of the entire supply chain, understanding the operational resource status and setting proper operational priorities in the chain.

For the management team, leaving operation teams drained of resources would put service performance in risk. The most resource-absorbing activities in IT-enabled SSC, in addition to regular operations and maintenance, are incident fixing and problem solving. Incident fixing, in particular, often drains a huge amount of operational resource very quickly. Since the highest priority in operations is to guarantee a continuous and reliable service provision, the impacted services need to be restored as soon as possible. Problem solving is not as urgent and demanding of resources as incident fixing, but it usually ties up resources for a much longer period.

The chain operational priority is interpreted in terms of operational resource allocation. The decision of chain operational priority should be based on a balanced assessment of innovation and operation performance. This means taking more account of both innovation and operational processes, and the causalities among them, so that the management team can recognize and facilitate the learning loop between these two processes. As mentioned above, incident fixing and problem solving are the two main ways in which resource are absorbed, they should be the main focus when deciding priority in resource allocation.

8.1.2 Unique features of IT-enabled SSC

IT-enabled SSC is a specific type of SSC that consists of the development, the operations and the management of IT-enabled services. This research confirms that it shares the common characteristics of SSCs, such as the importance of human factor, the continuous provisioning of service capacity, no inventory management but IUS, continuous provisioning of service capacity, inter-connected supply network (chapter 2.3, Table 2.1).

In addition, the findings from the three in-depth case studies reveals the following unique features of IT-enabled SSCs that result from the critical role of IT applications.

Critical impact of IT infrastructure on SSC performance

In SSC management, service quality is usually concerned about fulfilling customer needs and often measures customers' perception of service performance. Classic service quality models often separate the performance of service delivery process and service outcome into different dimensions [52] [56]. However such dimensionalization can not comprehend the complexity of IT-enabled SSC performance. The critical role of IT infrastructure requires a different way of perceiving and controlling the performance.

The role of IT infrastructure in service operations is distinguished in IT-enabled SSCs. In the SSCs [16] that are only IT-facilitated, service provision is accelerated by adopting IT applications, but is still possibly done in a conventional way without IT (Figure 1.2, SSC). Differing from that, IT-enabled service provision stops if one of the IT applications applied does not function properly (Figure 1.3). In IT-enabled SSCs, there is no substitution of IT infrastructure with other forms of service provision in operations.

The performance of the delivery process and the service outcome has close causal influence to each other and should be managed together in IT-enabled SSCs. This is because any anomalous performance of IT-infrastructure has direct and immediate impact on customers' perception of service performance. The service availability equals to the availability of IT infrastructure, which could be clearly seen from the incident management of IT-enabled SSC in both case two (Chapter 6) and case three (Chapter 7).

Surrogate interaction is the dominate process region in IT-enabled SSC

The interactions between providers and customers and among different tiers of suppliers are important operational activities in service provision. Sampson [35] classifies three types of interactions from process perspective, namely the direct interaction, the surrogate interaction, and the independent processing. All three types of interactions can be clearly recognized in the process model of IT-enabled SSC (Figure 8.1), but in unique forms with strong influence from IT infrastructure.

The direct interactions more often occur at the interfaces among the development process, operational process and the managerial process, but only function as facilitation. For instance, the meetings between the innovation team and the operations team, or the management report meetings. The actual production of IT-enabled services is conducted as independent processing within the development process and the operational process, such as the application development, the service implementation, incident fixing and so on.

The dominant process region in provisioning IT-enabled services is the surrogate interactions in which non-human resource is involved. This is because all core service operations are conducted via telecommunication platform, such as the mobile network configuration in case one (Chapter 5), the service monitoring in case two (Chapter 6), or the incident fixing in case three (Chapter 7). This platform is highly interactive and is made of various IT applications, which makes direct interaction between human resource not possible.

Human performance is associated with stakeholders' operational knowledge of IT

Human performance is critical to successful service operations [77], and the same is also found true in IT-enabled SSC. Given the dominance of surrogate interactions in IT-enabled SSC, the human performance is in close relation to service stakeholders' operational knowledge of the technical environment.

Core operational activities in IT-enabled SSC consists of the development, the operations and management of IT-enabled services (Figure 8.1). The operational knowledge consists of the requirements, the solution design, the development progress, the implementation and the consequential impact on the overall performance of the IT-enabled services. As specified in the operational performance gaps discovered, the operational knowledge level and how this knowledge is shared among relevant stakeholders has big influence on the operational performance of IT-enabled SSC.

For instance, the productivity of contracted suppliers has strong influence on the service operation gap (case two, Chapter 6.3.2). The level of expertise and the communication effectiveness amongst stakeholders involved are included in the indicators for supplier productivity.

Divergent (technical) domain knowledge

Stakeholders involved in IT-enabled SSCs come from various (technological) domains. Despite the fact that IT applications are heavily involved in and are enabling service operations, IT is often not the only technical domain in the supply chain. This is partially due to the difference between two operational processes, namely the IT development and service operations. Additionally it is also determined by the technological complexity in operating IT-enabled SSC.

IT has the enabling role to make service operations possible in IT-enabled SSC. However the development and operation of IT-enabled service may require different types of (technical) domain knowledge. Software engineering knowledge is often required in the development process, while knowledge of a specific service domain is demanded in service operations. For example, in the IT delivery in mobile service operations (case one, Chapter 5.1.2), the business owner comes from telecommunications and is responsible for operating the mobile network, while the IT developer comes from software engineering and is only responsible for delivering the product.

An innovative IT-enabled service offer often consists of a series of (technical) operations and continuous improvement. The complexity of such operations demands various (technical) expertise and is also often the reason for outsourcing [77]. A good example is the service operations in fixed-line services (case two, Chapter 6.1.1). Different suppliers are responsible for the monitoring, the delivery and the maintenance of the service. The service provisioning results from divergent (technical) domains' joint efforts.

8.2 Contribution of combining IS and OM to IT-enabled SSC research

The importance and influence of IT-enabled SSC has grown so fast during recent years in relation to the trends of servitization and digital economy. This topic attracts interests from both information system (IS) and operations management (OM) research domains. However neither IS nor OM scholars have fully explored it or understand it. What this thesis has advocated is to bridge expertise and methods from these two fields and to obtain insights of the operational performance of IT-enabled SSC.

8.2.1 Combine IS and OM research on IT-enabled SSC

The scope of IT-enabled SSC falls into the intersection of service operations, supply chain management and information systems (Figure 1.4). Different aspects of this specific type of supply chain have been studied separately by researchers from various fields (Chapter 2 and 4). However the alignment of operational performance at different supply chain tiers needs to be achieved through a systematic approach and with comprehensive performance analysis.

In IS domain, research on IT-enabled SSC stems from service network modeling and design, and has an emphasis on the technological functions and configurations of web services (Chapter 4.2). In OM domain, IT-enabled SSC is considered as a special type of SSC and research efforts are drawn from service operations and supply chain management, and the research mainly focuses on exploring the phenomenon on the basis of classic OM and SC theories (Chapter 2.2 and 2.3). Both previous IS and OM research claim that they include both business and technical services in their vision of IT-enabled SSC, but they have their own interpretations on the scope and variety of 'business' and 'technical' services (Chapter 4.1.1).

The scope of IT-enabled SSC research in IS and OM has been expanded in this research. The framework proposed incorporates different research angles and methods into a holistic and actionable approach. Issues coming from IT development phase (IS domain) and service operations phase (OM domain) have been put together in performance analytics. Balanced emphasis is given on both business and technical aspects of IT-enabled SSC operations. The operational performance of IT-enabled SSC has been assessed from both structural and quality perspectives.

8.2.2 Combine design science and empirical research methods

In addition to a holistic scope of including IS and OM research, the combination of design science and empirical research methods also contributes greatly to accomplishing research activities. The framework (Figure 4.6) proposed in this thesis adopts *an explicit modeling approach* from the engineering based IS domain and *a set of analytics* from the social science discipline OM. The development of the framework follows the design science approach, while the design evaluation of the framework is conducted in empirical case studies.

The real world cases provide practical environment to demonstrate and validate the framework, and the framework steers the case studies in a structural format. The static modeling approach (Diagnostic phase in Figure 4.6) provides clear steps to collect, structure, categorize and generate performance data from extensive and descriptive case material. Instead of presenting narrative stories, the case information is organized in structural formats. This IS-centric modeling approach helps to generate the essential performance information from complex real world settings. The performance analytics (Therapeutic phase in Figure 4.6) employ the causal analysis and the system dynamics which are often used in OM research. These analytics dig into the detailed performance information and reveal the hidden operational gaps in complex IT-enabled SSC.

It is worth noting that every step involved in the framework serve as guidelines for different users. The data structuring approach may be better known to users who have enterprise architecture or business process modeling experience than to users coming from social science. On the other hand, the construction of causal diagram may come naturally to experienced OM researchers or system dynamics experts, but the four-step approach to causal relationship construction can provide instructions to others who do not receive trainings in relevant fields. In this way, the framework can be better adopted by different user groups and in a wider scope.

8.3 Demonstration of interdisciplinary research

As the thesis title suggests, this research aims to bring efforts from different disciplines into the research on IT-enabled SSC. The research activities carried out present a clear demonstration of interdisciplinary research.

8.3.1 It is a feature, not a bug

Interdisciplinary research is often considered as a risky path when it is associated with academic careers [30]. Nevertheless spanning academic boundaries contribute significantly to solving complex problems, and the value of interdisciplinary research is increasingly recognized as the modern society rapidly advances with technology development. In this thesis, being interdisciplinary definitely is a feature, not a bug.

The contributions of combining IS & OM and combining design science & empirical research to IT-enabled SSC have been emphasized above (section 8.2). The complex and in-depth insights of IT-enabled SSC (section 8.1) result from an interdisciplinary approach, which intends to provide a solution-oriented common ground, so that multiple service research communities can meet together.

Following the framework proposed in this research, services, at different tiers of an SSC, are modeled with a balanced perspective on both business, technical service components and KPIs. It allows a holistic picture of service performances and interactions throughout the entire supply chain to be viewed through a different research lens and permits the causal impact of technology, business strategy, and service operations on supply chain performance to be unveiled.

8.3.2 Recommendations for interdisciplinary researchers

Conducting interdisciplinary research is challenging. It is always a bit exploratory to identify its research path, as it often does not belong to any well established research field. However the importance of such type of research has been widely recognized and more researchers are trying to expand their work into more complex problems [187]. Having a difficult interdisciplinary research demonstrated in this thesis, a few lessons learned can be shared with those who would like to join this inspiring research path. This may be especially helpful to young researchers who just or decide to begin interdisciplinary.

Do not claim it interdisciplinary while simply being multidisciplinary

What type of research it is called would seem not to change the research outcome much. However it may influence the way how participants collaborate and indirectly has some impact on the results. There is a big difference between being interdisciplinary research and being multidisciplinary research. It is determined by the extent of knowledge integration from two or more than two disciplines in researching the chosen subject [188].

A good metaphor to explain the difference between these two types of research is the 'Composition' and 'Aggregation' relationship in UML class diagram [189]. Both types of research attracts research attention and efforts from multiple disciplines. In a multidisciplinary research, researchers from different domains are 'aggregated' to work on the same subject from their perspectives, either separately or collaboratively to certain extent. An interdisciplinary research requires researchers from various fields to collaborate closely, since the ultimate research outcome is a 'composition' of their knowledge and experience which is complimentary to each other in achieving the results.

It is recommended to think clearly about the objectives and requirements of the planned research. The type of research determines how researchers collaborate, communicate and contribute to the research outcome.

Let research objectives determine the research methodology

Every research discipline has its mainstream research method which is based on the main focus and establishment of the field. For instance, natural science and a major section of social science use empirical method to capture and to characterize the physical systems, while design science follows solution oriented engineering approaches.

Including different research domains in one interdisciplinary research implies that it tries to integrate various research perspectives and expertise. It is worth remembering that the research methodology needs to be determined by clearly defined research goals, otherwise the research may run risk of losing focus and leaving research outcomes uncompleted.

The research presented on IT-enabled SSC has both engineering and empirical aspects, namely the framework design and the case studies. Although the outcome seems to be twofold, the case insights and the validated framework, the research clearly followed a design science research path and the insights obtained from case studies were used to validate the effectiveness of the framework designed. It is because the primary research objective is to find a proper method for aligning operational performance of IT-enabled SSC.

For research that is grounded in more than one discipline, it suggests to determine research methodology according to the main research goal. Every research discipline seeks specific types of problems and outcomes. Interdisciplinary research, however, focuses on integrating different research strengths to solving a new problem. All research efforts should be involved in the way that fits best to finding the answer.

Clarify the language first

Please always be aware that there might be discrepancy in the interpretation of concepts used in conversing with people from different disciplines. Every research discipline has its own scientific vocabulary and jargon, and some disciplines may share the same term but their interpretation vary. The confusion in the shared service terminology (Table 4.1 in Chapter 4.1.1) is a good example to show the importance of conceptual clarity in interdisciplinary research. The bridge that this research tries to build, in the first place, is a communication channel among the disciplines involved.

Please do not presume your research fellows acknowledge the actual context, and please always explain the research standpoint. Special attention should be paid during the interviews with field experts who tend to use jargon, since they do not have the habit of nor need to explain their work to laymen. Please do not feel embarrassed about asking for clarification of words. A clarified language is very important in developing interdisciplinary research [190].

Be a good coordinator and take lead in the research

Bridging different scientific disciplines is based on tremendous cross-domain cooperation, and researchers from different fields may find unique interests in interdisciplinary subject which is often driven by various goals [191]. While having many great minds gathered in one project, it also creates a special coordination task for interdisciplinary researchers.

The project leader of an interdisciplinary research needs to be careful with steering research efforts towards the expected research outcome. It is imperative to keep in mind that the research goal is to create synergies from the participating research fields. The leading direction of all research capacity needs to be in compliance with the research objective and should not be 'distracted' away from that. All research efforts should contribute to the research outcomes. There might be moments that some researchers feel frustrated with their research ideas not being selected, which should be considered as a necessary compromise in interdisciplinary research.

A service oriented mindset is always helpful

In addition to the above recommendations, another useful tip is to have a service mindset in conducting interdisciplinary research. Services, given its primary function in exchanging values, are always goal oriented. All service activities aim to satisfy customer needs directly or indirectly. This mindset can be borrowed in interdisciplinary research that the main focus is on creating synergies among research disciplines involved.

8.4 Conclusion

This chapter summarizes the contributions of this thesis from different dimensions. The *outcome* of this research contributes greatly to the knowledge base of IT-enabled SSC by revealing three operational performance gaps and unique features of this specific type of SSC. The *approach* in which this research was conducted contributes to bridging two research communities, viz. the IS and OM, and to connecting two types of research, viz. the design research and the empirical research. The *lessons learned* from carrying out this research provide practical guidelines for (junior) researchers who work on interdisciplinary projects.

CHAPTER 9

DISCUSSIONS AND CONCLUSIONS

> The philosopher Tsang said:"I daily examine myself on three points: whether, in transacting business for others, I may have been not faithful; whether, in intercourse with friends, I may have been not sincere; whether I may have not mastered and practiced the instructions of my teacher."[1]

Having an attempt to emulate the ancient wisdom, this dissertation is concluded by reflecting on three aspects of the presented research. In retrospect, we check whether the research has been conducted following an appropriate approach (section 9.1); whether the proposed service network diagnostic framework fulfills the research objectives (section 9.2); whether the cases selected have been properly studied and provide sufficient material (section 9.3). Finally, the research is concluded by highlighting research implications and future work (section 9.4).

9.1 Discussion on research method

The approach (Figure 1.5) within which this research is conducted is a synthesis of four valid research methods: the design science research, the process research, the case research and the action research. Having triangulation of research methods in information management research is not new. The methodology behind this research design has been illustrated in Chapter 3.

The intention of finding an effective operational performance alignment method for IT-enabled SSC in this research is consistent with the artifact-oriented objective in design science. The research follows design science research steps to investigate op-

[1]Chapter 4, Book I, The Analects of Confucius

erational performance alignment issues in the context of IT-enabled SSC, design and evaluated the propose service network diagnostic framework in real world case studies. The solution orientation and combination of multiple perspectives for knowledge creation in design science fit very well with the objectives of this research.

Regarding the context of researching operational performance alignment in IT-enabled SSC, relevant works (chapter 2) are reviewed and literature gaps on this issue are identified. Based on the identified problem and current solutions found in the literature, the service network diagnostic framework is proposed (chapter 4). This framework is the design artifact of this research, and is evaluated through an iterative problem-solving process.

In the design evaluation phase, the designed framework is implemented to solve problems through three iterations of case studies. The design evaluation depends heavily on the implementation results and is helped by employing an iterative process research approach to obtain rich insights into organizational changes. Each case study is one iteration and the framework is improved at the end of every iteration.

Real-world settings of IT-enabled SSCs provide empirical contents for the application of the designed framework. In every case study, the applied framework aims to discover and solve one particular problem, from which new insights into the IT-enabled SSC is generated. This actionable problem-solving approach has a clear flavor of action research and is a proper validation method for the implementation of the framework.

Thus this research method is grounded in a mixture of valid research methodologies. The expected design artifact has been finalized and verified throughout this approach.

9.2 Discussion on framework design

The proposed framework (Figure 4.6) is expected to be an effective working method to discover and align operational performance gaps in IT-enabled SSC. The design of this framework (chapter 4) reflects the 'best of breed' manner, which incorporates various modeling and analytical methods across several fields of service studies. The framework can be considered as a satisfactory guidance for bridging operational performance gaps in IT-enabled SSC.

The two-stage structure of this framework, viz. the diagnostic phase and the therapeutic phase, steers the framework with a clear, staged focus on the discovery and alignment of operational performance gaps respectively. The objective of this framework design is to reveal the actual problems in the context of IT-enabled SSC, and tackle them in an effective manner. It is oriented towards finding practical solutions.

The diagnostic phase instructs users to approach the problem through a step-by-step exploratory modeling process. A fixed position is maintained in structuring the collected information, as the proposed six SCC core elements that combine the perspectives of business and IT are leveraged to a meta level. It allows users to break down the complex supply chain into modular services, so that a clear overview of all the services involved, and all interactions among service participants, comes to light. Each modeled service is carefully assessed with respect to the criteria generated from these core elements, and this leads to the generation of hierarchical and categorized sets of KPIs. Thus every performance issue is traceable to its root cause, and performance gaps can be easily located in SSC.

The therapeutic phase further guides users to delve deeper into the insights gained and to seek alternative resolutions to the problem uncovered. Modeling continues here in the performance causal analysis. The causal relationship construction approach provides clear and progressive instructions on how to explore and construct causal relationships among performance indicators. The causal diagrams serve as the basis for building system dynamics simulation models. The performance causal analysis helps to transform case narratives to the building of system dynamics models. As assessed by simulation models in case two and case three, different scenarios are evaluated, and attempts at bridging each performance gap is made from the simulation analytics.

The proposed framework is well designed and evaluated. Chapter 4 presents the design of the framework. Three design objectives lead to build the framework that uses clear terminology, comprehends state-of-the-art modeling and simulation approaches and is structured in a best-of-breed manner. An iterative development and demonstration [192] of the framework shows its incremental improvements from being applied to three case studies.

The framework is flexible to incorporate new methods and approaches on the basis of case conditions. In the current final version of the framework (Figure 4.6), all analytics in the therapeutic phase were added from different case studies and are kept optional. Depending on case conditions, it is still possible to adopt other methods for specific performance analysis. The gap formalism reflects the structure of operational performance in different case conditions, which offers a clean overview of performance factors and could be easily adjusted and tuned for performance improvement.

However it is still presented with a high level of abstraction. The author prefers to keep the framework in a simple form, as it functions mainly as a 'bridge' between various existing modeling and analytical methods. Thus the design activities focus on validating the structure of this framework, rather than specifying the details of each modeling an analytical method involved. Nonetheless, it is a reasonable recommendation to further specify and customize modeling guidelines when using them in different case settings or environment.

9.3 Discussion on case studies

The research objective determines the role of case studies in the research approach within which this research is conducted (section 9.1). The case settings provide practical environment to gain insights into IT-enabled SSCs and to evaluate the framework that has been designed. In this section, the discussion focuses on whether the cases selected provide sufficient material and produce valid outcome.

All the cases studied in this research come from one company in the telecommunication industry. A good case should reflect the core research context that, in this research, is the operational performance alignment in IT-enabled SSCs. Telecommunication services are fully driven by IT and their supply chain is extremely complex and dynamic. The performance gaps discovered in the case studies (chapter 8.1) explicitly show that the research material from this industry is rich and fits the subject of the research.

The number of cases used in this research (three), which is slightly smaller than the ideal number of cases for qualitative research (four - ten cases) [31], still works well to obtain significant detail of one complete IT-enabled SSC. These cases come from the same type of technical environment and present different service domains and tiers of the supply chain. Just as suggested in [193], the fewer the number of cases, the greater the opportunity for depth of observation.

The limitation of the chosen cases is with respect to the design evaluation. All the cases come from the same company in the same industry. This directly raises the question of the generalizability of the proposed framework when it is applied in other IT-enabled settings and context. Nonetheless, the case company has a dominating role in local market and provides rich and diverse research material. During the process of design evaluation, having all cases from the same company offers the flexibility to refine the design in an inexpensive manner [6].

9.4 Conclusions

The research presented in this thesis can be considered as the first successful step to revealing, assessing and bridging operational performance gaps in increasingly complex service supply chains where many IT-enabled services are delivered. Researchers and practitioners from multiple disciplines have been dreaming and are still trying to bridge business and IT for decades. This research carries on the dream and proposes an effective framework to establish bridges across the gap. The proposed framework is grounded in theoretical background and real-world findings, and successfully embraces a set of established modeling and analytcial methods. This best-of-breed composition is light-weighted, effective and innovative.

Having all the above summarized, it is confident to conclude on the following three issues in relation to the validity of this research.

1. The research has been conducted following an appropriate scientific approach.
2. The proposed framework fulfills the requirements of discovering, analyzing and bridging operational performance gaps in SSC.
3. The selected cases are suitable for the researched subject, and lead to fruitful and inspiring findings through a well structured and validated approach.

For service researchers

Technology advancement is continuously transforming services and SSCs in the direction of digital, highly automated and smart forms, and will continue to do so. The alignment between business demands and IT performance has never before been so critical to business success: the role of IT applications has changed from supporting business to being core business themselves. Alongside the wide spread of IT applications, the concept and roles of business and IT changes over time. Resetting a new baseline for operational performance alignment is necessary in the current context of service research.

The research presented in this thesis examines the operational performance alignment issue in IT-enabled SSC and makes a modest contribution towards discovering and bridging operational performance gaps in this specific type of supply chain. What this research has advocated with respect to this is to provide an instrument which can modularize complex SSC in terms of a hierarchically-structured set of services. With a special focus on the impact of IT, it makes it possible to monitor and tune various performance issues in SSC.

This research intends to provide a solution-oriented common ground, so that multiple service research streams can meet together. Following the framework proposed in this research, services, at different tiers of an SSC, are modeled with a balanced perspective on both business, technical service components and KPIs. It allows a holistic picture of service performances and interactions throughout the entire supply chain to be viewed through a different research lens and permits the causal impact of technology, business strategy, and service operations on supply chain performance to be unveiled.

For service practitioners

In highly automated SSC, the risk of service impact escalation is present but hidden in any change made in the chain and does not manifest itself directly. Because of technological complexity, the service impact cannot be detected in advance but is perceived by customers immediately. This echoes the findings of the bullwhip effect in highly automated processes [21]. Therefore it requires that service strategies are developed that give consideration to performance causality throughout the entire SSC.

Technology advancement drives service innovation in IT-enabled SSC. The actual innovation activity is IT development. The supply chain coordination is heavily influenced by the acquisition of domain technological knowledge. Given the technological complexity of the integrated platform for all IT-enabled services, it is necessary to have a holistic innovation road map for SSC coordination. However, achieving such an alignment in practice is immensely challenging, as each service stakeholder involved has its own innovation planning. Service practitioners need to be aware of the stakeholders' diversity and the supply chain's complexity when planning and managing their innovation activities.

Future work

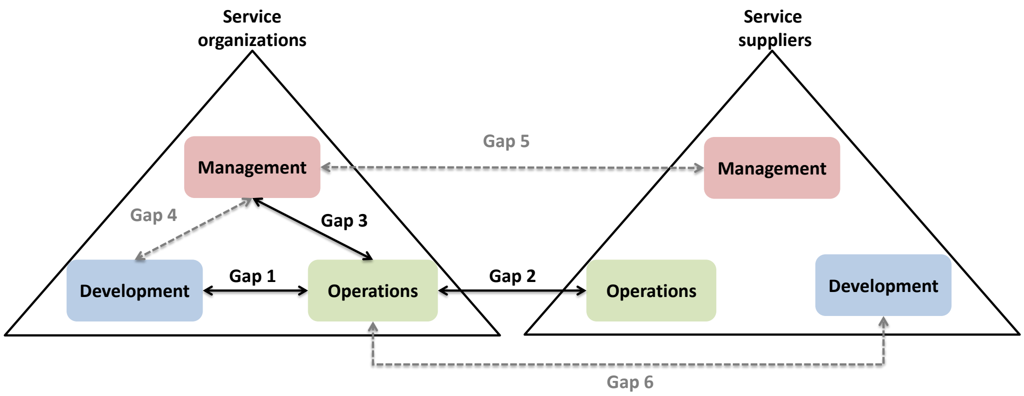
This research is exploratory, therefore it leaves room for follow-up research. The future work in relation to the limitations of this research has already been introduced in chapter 1.6. In this section, it calls for more interdisciplinary research on the exploration of potential performance gaps in IT-enabled SSCs.

Figure 9.1 depicts the overview of performance gaps in IT-enabled SSCs. This overview is based on the insights into IT-enabled SSCs obtained in this research. Discussions about the first three gaps (Gap 1, Gap 2, and Gap 3) can be found in chapter 8.1. Case replications with respect to these gaps are demanded in different IT-enabled SSC settings and context.

Service innovation in IT-enabled SSC is in close relation to IT development. Given the high innovation rate in IT-enabled services, it is interesting to examine the relationship between top management and IT development (Gap 4). Within an service organization, service innovation strategy is made by the top management and is carried out by the IT development. More insights into the interactions between top management and IT development are demanded.

Outsourcing is an important element in service operations and IT advances service outsourcing. In general, service organizations choose to outsource the services that require less intellectual property but large number of people [22]. Differing from that, the outsourced service operations in IT-enabled SSCs are often critical and core processes to the business service success (e.g. case two in chapter 6). More research attention should be paid to the relationship and collaboration between service organizations and their suppliers in IT-enabled SSCs (Gap 5 and Gap 6).

Figure 9.1: Performance Gaps in IT-enabled SSCs



APPENDIX A

APPENDIX

A.1 Acronyms and Glossary

BIA Business and IT Alignment

BSC Broadcast Service Center

BTS Base Transceiver Station

D&S Demand & Supply

E2E End-to-End

EssUP Essential Unified Process

FO Fixed Operations

GNOC Global Network Operation Center

I&O Infrastructure & Operation

IMS IP-based Multimedia Subsystem

ISP Internet Service Provider

KPI Key Performance Indicator

MExNet Media Exchange Network

NOC Network Operation Center

NPVR Network Personal Vedio Recorder

OMC Operation and Maintenance Center

PA&M Program Assurance & Methods

PMO Program Management Office

QoS Quality of Service

RANOS Radio Access Network Operation Support

SPOC Single Point of Contact

SQC Service Quality Control

STB Set-top box

TDM Time Division Multiplex

TI Technical Infrastructure

TTRC Technical Testing & Release Center

UCM Use Case Module

UCS Use Case Specification

UCR Use Case Realization

VOD Video On Demand

VoIP Voice over IP

WBA Wireless Broadband Alliance

W&O Wholesales & Opeartions

A.2 Case Background and Setting

KPN is a Dutch leading telecommunications and ICT service company, offering wireline and wireless telephony, internet and TV to consumers, and end-to-end telecommunications and ICT services to business customers. In the following sections, three cases selected from different services provided by KPN Nederland are presented. During the 2-year case study period, KPN was experiencing a company-wide reorganization. Huge changes took place in the organizational divisions, expertise reallocations, supplier collaborations and so on. In each case presentation, the involved departments / organizations are refered by their titles at the time when case material was collected. When there is a need of cross-case reference, additional explanation will be provided.

A.2.1 KPN Organizational Structure

By mid 2011, KPN Nederland included several subsidiaries, namely Nederlandse telecomactiviteiten, Getronics (ICT providers), iBasis (wholesale VoIP service, main providers to Gtalk and skype, transport all the traffic around the world), Mobile International and Other activities. Within Nederlandse telecomactiviteiten (Figure A.1), there are four main units:

Consumer Market (CM)
CM had about 3,000 employees, and provided mobile services, fixed services and TV services for customers. The KPN call centers also belonged to the CM.

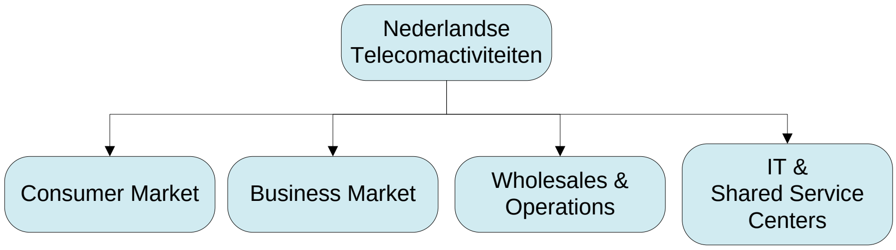
Business Market (ZM)
ZM had about 3,000 employees, and provided mobile services, fixed services and, particularly, data network services for business partners. The data network services included, for instance, the network operated between the automated teller machines (ATM) which is connected with the data center of big banks. All the banks in the Netherlands use KPN's data network for that.

Wholesale & Operations (W&O)
W&O had about 4,000 employees. It offers all kinds of wholesale services, such as managing all the networks and customer connections for different KPN services, managing the real estate of KPN, as well as serving as a big operational unit that dealing with all technicians, and so on.

IT and shared service centers
The fourth unit was dealing with all the IT and shared service centers. ITNL was the biggest department here, and has about 800 employees.

Within ITNL, a more detailed organizational chart can be found in Figure A.2. ITNL was lead by CIO John Wittekamp, and consisted of four managerial departments and five IT departments. Managerial departments included the CIO office, the Finance department, the Human Resource department and the Program Assurance & Methods (PA&M) department. The responsibility of Finance department was further divided into three major areas, namely the Compliance where stood an internal legislation group within KPN, the Business Control where the investment control was managed, and the Program Management Office (PMO) where showed the innovation of IT departments as well as the IT of other departments from program managment's point of

Figure A.1: Organizational Structure of Nederlandse telecomactiviteiten by mid 2011



view. The PA&M ran innovation for IT, network, business and consumer market. Both the PMO and the PA&M worked not only within ITNL, but also faced the innovation programs at company level.

The five IT departments in TINL provided IT services for different business KPN units. ITVolume receive business requirements from consumer / business market or a produc unit for IT supports. ITOSS & ZM Value receive business requirements from W&O, and provide operation and supporting system for managing the network, as well as for the business market and valued customers. ITMobile support KPN mobile services, and receive business requirements from KPN Mobile International. IT-Generic & Traditional offer generic IT services including huge database of business information. They receive business requirements from Finance department. Infrastructure & Operation (I&O) take care of equipments and data centers. The data centers are owned by Getronics. Getronics do their demands and also have their own data centers.

Structures within these five IT departments are similar. There is 1) an operational manager available for all the maintenance, 2) an innovation manager running all the innovation projects within the department, and 3) one delivery manager reporting to the innovation department. The delivery manager runs all the projects and does all the implementations in ZM, CM, as well as the other areas. They are responsible for all the architectures. Business consultants are working in the delivery sections, where they work together with architects from the innovation departments in W&O, and translate the business requirements into functional design that could be implemented in the systems.

The company-wide re-organization took place since early 2012. In the new divisional structure (Figure A.3), CM is split into two new segments, the Consumer Residential (internet, television and fixed telephony) and Consumer Mobile (mobile telephony and mobile internet). Meanwhile the W&O and ITNL are combined into a new segment NetCo. In several KPN services, some service operations and developments are gradually outsourced to contracted third party suppliers. This move reflects KPN's strategic plans towards a simpler organization, which aims to facilitate a more

Figure A.2: ITNL Organizational Structure

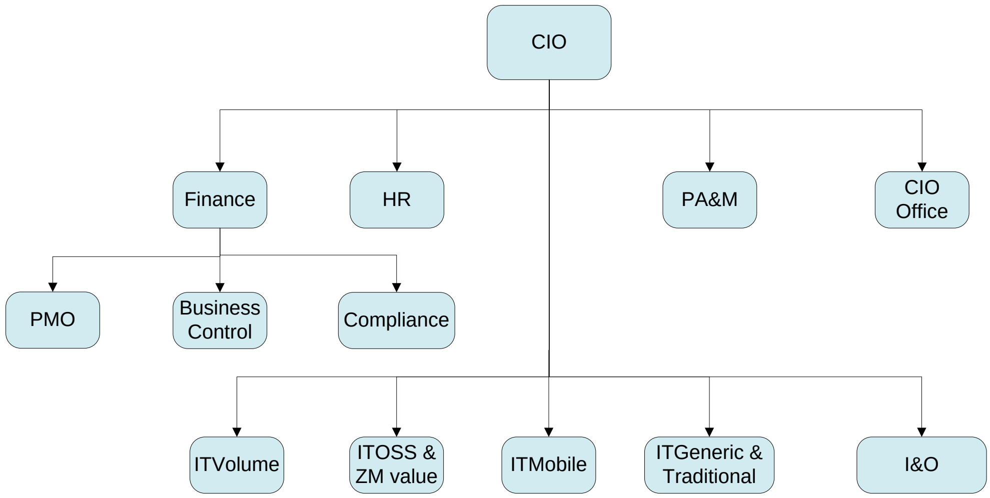
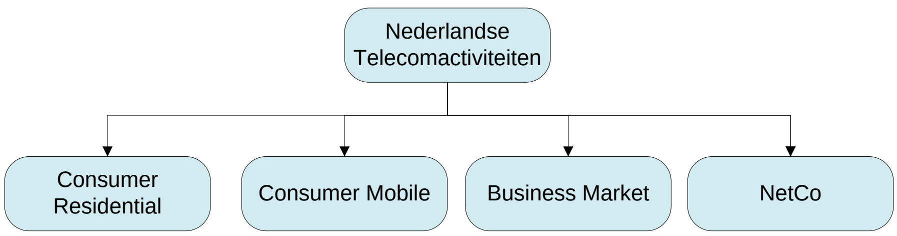


Figure A.3: Organizational Structure of Nederlandse telecomactiviteiten since early 2012



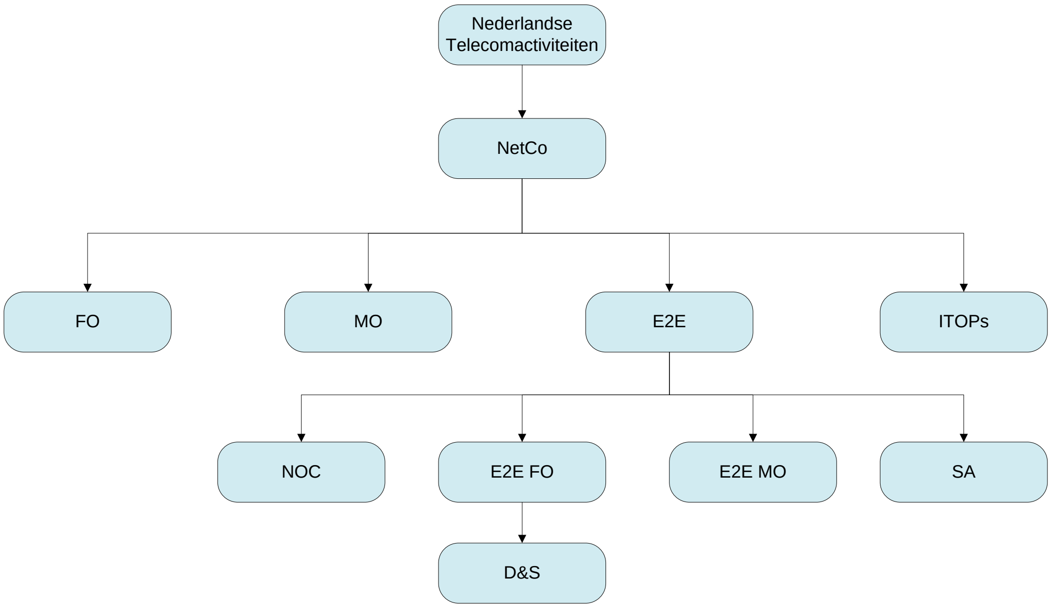
direct and efficient management, so that it will be more responsive in the dynamic ICT world.

A.2.2 KPN NetCo Performance Management

Within NetCo (Figure A.4), the main operation departments include the fixed operations (FO), the mobile operations (MO), the IT operations (ITOPs, formerly known as ITNL), and the end-to-end (E2E). The FO and MO are concerned about operations of network infrastructure and capacity. The E2E, where this case study was conducted, takes care of the service continuity over the supply chain of KPN's telecom service deliveries. It consists of several functional departments, for instance, the network operation center (NOC) who performs the network mornitoring, the E2E FO and E2E MO who run the daily operations of fixed-line services and mobile services, and the Service Assurance (SA) who guarantees all delivered services over fixed network. As the outsourcing is taking place in fixed-line operaitons, a new department, the Demand & Supply (D&S), is formed in E2E FO whose tasks include steering and managing the outsourced service operations.

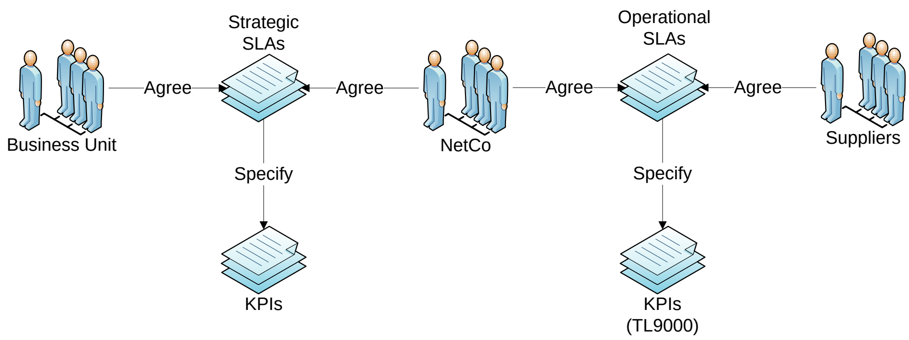
In general (Figure A.5), NetCo serves between KPN business units and contracted

Figure A.4: Organizational Structure of KPN NetCo



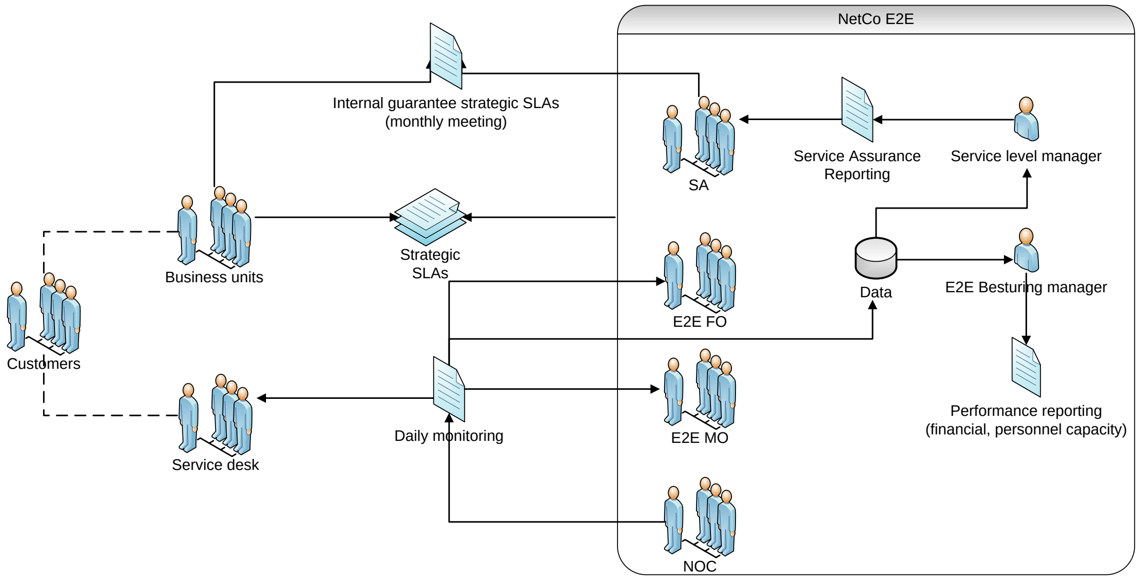
third party suppliers. There are signed Service Level Agreements (SLAs) between NetCo and business units regarding the delivery of telecom services at strategic level, and SLAs between NetCo and contracted suppliers at operational level. The Key Performance Indicators (KPIs) specified in strategic SLAs are used to measure the quality of NetCo services to business units, while the KPIs specified in operational SLAs provide requirements on suppliers' services to NetCo.

Figure A.5: Performance Management Structure of KPN NetCo Operations in General KPN Supply Chains



More specifically, Figure A.6 shows how the strategic SLAs between NetCo and business units are guaranteed. Customres have direct contacts with business units and service desk (e.g. call center), where they receive service contracts and customer services respectively. NOC provides daily monitoring on the service operations and performance at both NetCo E2E operations departments and the service desk. Both the E2E Bestruing manager and the service level manager come from SA. The detailed service performance data from the monitoring is analyzed by the E2E Besturing manager for performance reporting on financial reporting and personnel capacity. The monitored KPIs is sent to the service level manager for service assurance reporting, which is presented at monthly meeting, internally between business units and SA, to check whether the stragetic SLAs are met with current service operations.

Figure A.6: Detailed Performance Management Structure between KPN NetCo Operaitons and Business Units



A.2.3 Mobile Service

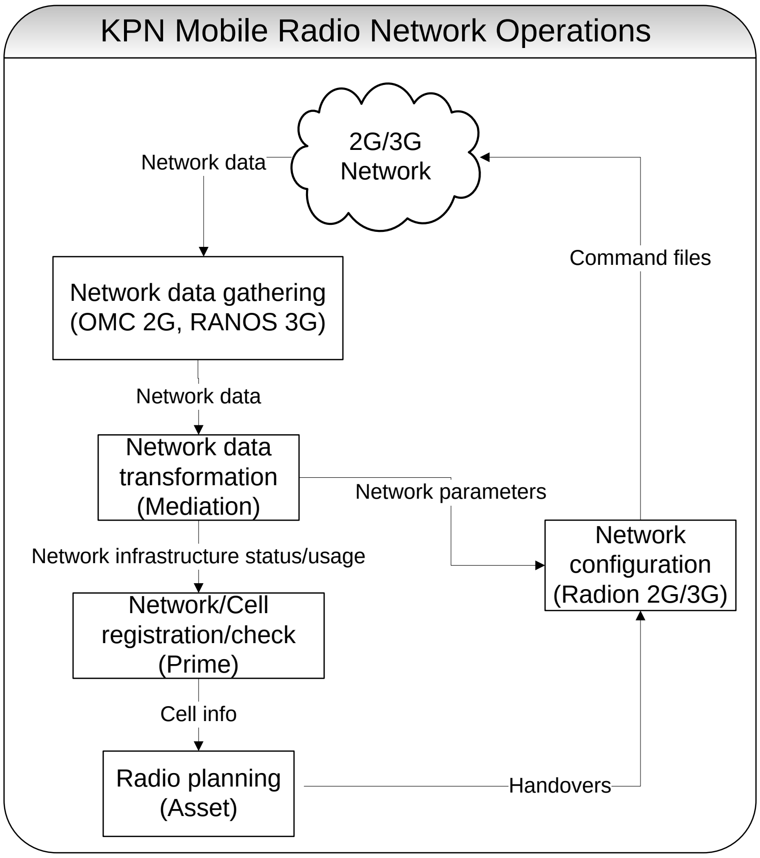
KPN services, such as mobile services, internet services and television services, are fully based on and delivered through technical infrastructures (TI) services. Typical TI service operations include running, maintaining and innovating their telecommunication network, for instance the 2G / 3G mobile radio network. Most of the TI service operations are managed in IT systems.

A.2.3.1 Mobile radio network operations in a nutshell

The operational process of providing mobile services is mainly about operating and maintaining the mobile radio network. Figure A.7 depicts the operational process in the mobile radio network, which involves operations like Network data gathering, Network data transformation, Network/Cell registration/check, Radio planning and Network configuration.

The 2G / 3G network parameters and network infrastructure information are gathered in the network Operation and Maintenance Center (OMC) for 2G and the Radio Access Network Operation Support (RANOS) for 3G respectively. All these network data is transformed into IT systems through the server Mediation. Prime is the registration system that registers network and cell sites, and checks the status and usage of infrastructure. The information of network infrastructure status and usage goes into the Prime system for generating the information of all cell sites. The cell info states what transmission lines go from central-based locations to the distributed locations, what hardware are at base stations, and the list of existing cells. The cell info goes further into the radio planning system, namely Asset, where it tells what all the handovers are between all the cells so that it can forecast parts of the desired network parameters and cell site coverage. Both the actual and desired network parameters will be imported into the radio control system Radion, where changes based on the imported information will be updated in the network configurations. The configuration decision is made according to the regional teams' interpretation of the network performance based on their experience.

Figure A.7: Mobile Radio Network Operations



A.2.3.2 Daily optmization process for network configuration

For the mobile radio network, network configuration is one of the most important operations. The 2G / 3G network parameters, as well as the network infrastructure and site status, must be checked and maintained on daily basis. If zooming into the network configuration in Figure A.7, there stands a daily optimization process for 2G / 3G network configuration. This optimization process, illustrated in Figure A.8, includes collecting network parameters from Asset and the network, integrating the desired changes and creating the new command files with parameter adjustments. The new command files will be implemented in the 2G / 3G radio network, so that the network parameters are updated.

This daily process starts at 10am from Mondays to Thursdays, and is mainly done in Radion while Asset and Mediation are also used for collecting network data. As the start of the configuration, Asset files are created and copied to the Radion server. The Asset files contain Base Transceiver Station (BTS) parameters and the handovers[1] between all the cells. In the following steps, two types of data will be imported into Radion, namely the network parameters and the handovers. The network parameters are imported automatically from the actual network without any human intervention through OMC / RANOS, and put in a big FTP file at the server Mediation every morning for the RT import. The RT makes changes to the network parameters according to their configuration decisions and merge the changes into parameter tables. The time spent on the table merge depends on the number of handover creations, which mainly comes from the Asset import. In addition to that, it is also allowed to create or remove (new) handovers during the configuration process. The merged tables will be imported again at RT for consistency check. This check includes the business rule check in total network and the asymmetrical handovers check. Once the consistency check is finished, new command files are produced in Radion at the end of every working day. Another department will take the new command files before 10pm on the same day, check the files and then put them into the network from 10pm till 2am the next day. Till then the network elements are re-configured essentially.

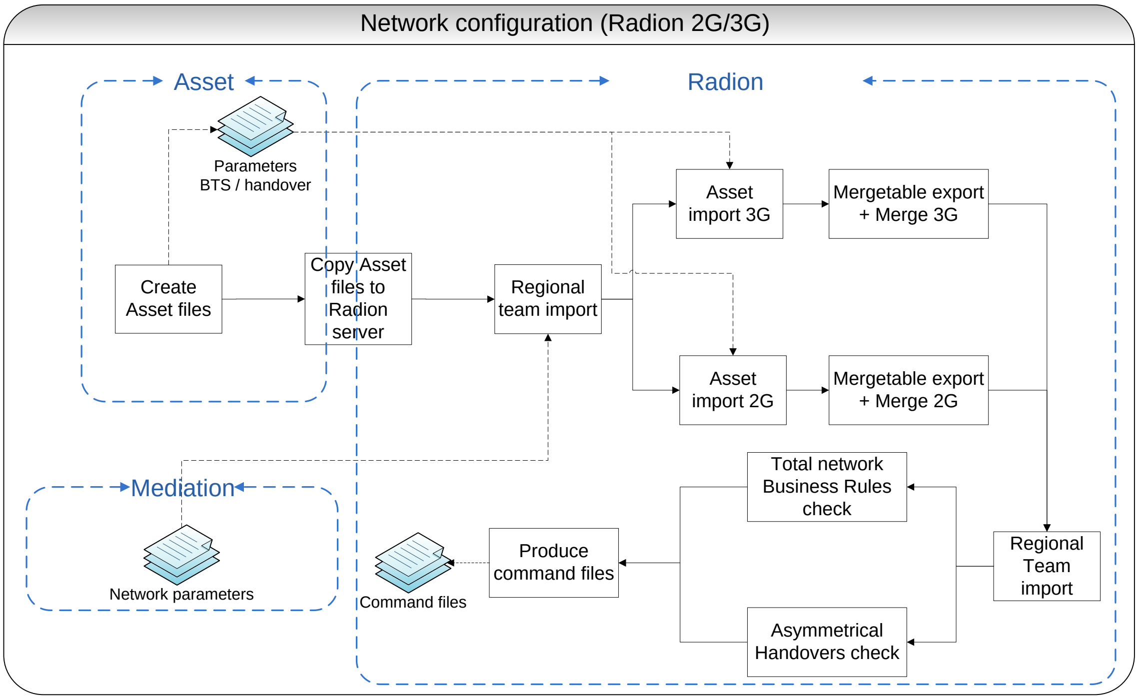
A.2.3.3 The steering departments of the innovation project

Managing such innovation project requires joint efforts from numerous departments (Figure A.9). Despite the W&O Innovation, ITNL ITOSS innovation and the contracted IT developer Ordina being involved in the actual development process, there are at least four other departments steering the innovation program from KPN side:

- The Process Assurance& Method (PA&M) department from ITNL set their scope on the complete innovation of KPN, and has the main goal to improve Innovation performance and support the innovation programs with: uniform innovation processes and tools, performance metrics, program assurance, quality man-

[1] Handover: the process by which a mobile telephone call is transferred from one base station to another as the subscriber passes the boundary of a cell (the geographical area covered by one base station).

Figure A.8: Configuration Management: Daily Optimization Process



agement and improvement programs and so on.

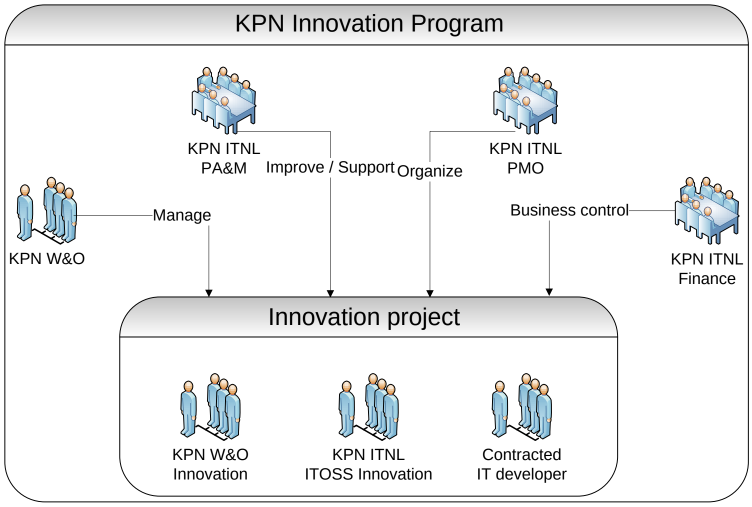
- Business controllers from ITNL Finance department take care of the performance of both the operation and innovation departments from business and financial perspectives. They collect performance data from weekly manager meetings and help the ITOSS management team to get everything in these departments financially in order.

- Each innovation program management team has program manager, business controller, and also a single point of contact (SPOC) person from the Program Management Office (PMO). The SPOC is organizing the program including all the projects, and providing the performance dashboard.

- The W&O is financially responsible for the innovation projects. There are program managers coming from W&O managing the projects and receiving reports from ITNL innovation managers.

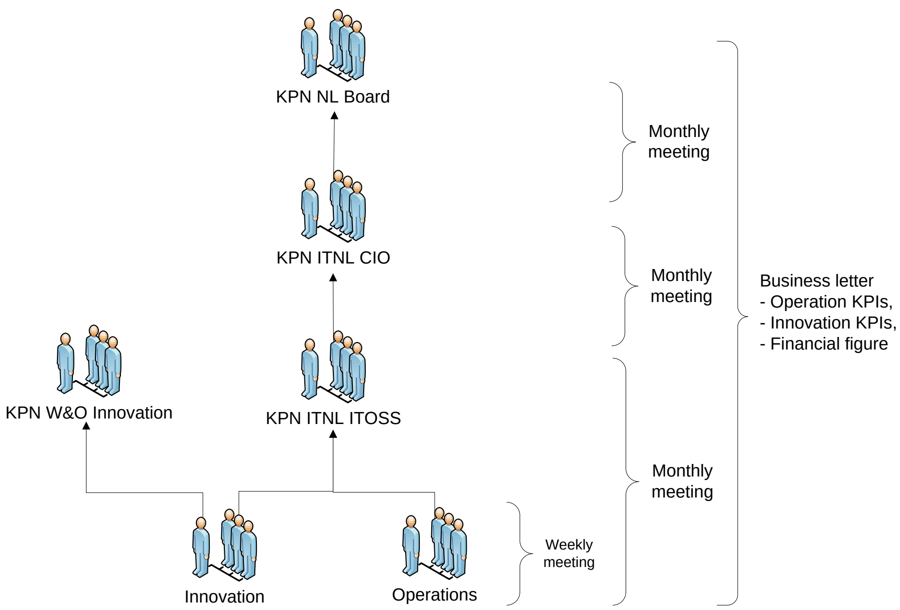
The performance reporting to management team is done through weekly and monthly meetings at different management level (Figure A.10). The performance data received at Finance department comes from weekly meetings within operations and innovation managers. Every week the operation KPIs and innovation KPIs are discussed during the meeting. As the innovation project budget is always separately accounted in W&o and ITNL, the ITOSS innovation managers also do weekly report to W&O innovation.

Figure A.9: The Steering Departments in KPN Innovation Program



Each month there is a review meeting within ITNL ITOSS, where all the information regarding the operation KPIs, innovation KPIs and financial figures are gathered at the ITOSS management team. Then the ITOSS management team reports the ITOSS performance to the ITNL CIO, while the ITNL CIO reports to KPN NL Board in their monthly meeting respectively. Management letter is used for carrying out all the information at different levels of reports.

Figure A.10: Reporting System from ITNL ITOSS's perspective



A.2.4 Fixed-line Service

A.2.4.1 Service operations overview

Within KPN NetCo E2E FO D&S, there runs the following 13 service operations to guarantee the service deliveries stay in control:

Incident management
: Incident management manages the life cycle of all incidents, and has the goal of providing prompt response to incidents, organizing available incident fixing capacity and restoring impacted services within agreed solution time.

Problem management
: Problem management aims to identify all the problematic issues concerning service performance, and manages the life cycle of all problems. Attention in problem management should also be paid on the correlations between incidents and problems.

Change management
: Changes in managed services come from new projects, planned problem resolutions, or emergency changes. The implementation of changes may have impact on perceived service performance at customer side. Change management supports and controls the life cycle of all changes, from the acceptance till the roll out of the changes.

Release management
: All the changes in managed services are executed in a series of releases. Release management takes care of the release roll out, with respect to capacity allocation, on time delivery and implementation quality.

Projects
: Supports for managed service providers in all projects conducted with KPN NetCo E2E FO is provided here. The projects include the ones initiated for solving identified problems, as well as the ones initiated for approved changes in managed services. It aims to facilitate project capacity allocation, on time delivery and first time right acceptance of all projects.

Configuration management
: This is an operation mainly for maintaining the configuration items that are required for end-to-end service delivery in the telecom network. It regularly checks information of all configuration items with repect to the unauthorized changes and the physical verifications of the configuration items in infrastructures. In addition, it facilitates capacity allocation for the physical verifications

and makes sure that all the configuration data is well kept in the configuration management system.

Capacity management
Capacity management provides monthly forecast on both finance and personnel capacity for KPN NetCo E2E FO. The forecast is made with respect to the customer base, the fulfillment of service orders and the on time deliveries.

Performance management
Performance management is concerned about the network efficiency. It manages the traffic supervision and platform interaction in the telecom network.

Availability management
Availability management defines, plans, analyzes, measures and improves the preventive maintenance in the telecom network.

Life cycle managements
The life cycle of the hardware, software and systems inventory of the platform in the telecom network is managed here. It makes sure that the percentage of defective service transactions is in control.

Service management
Service management manages the internal SLAs between KPN NetCo and business units.

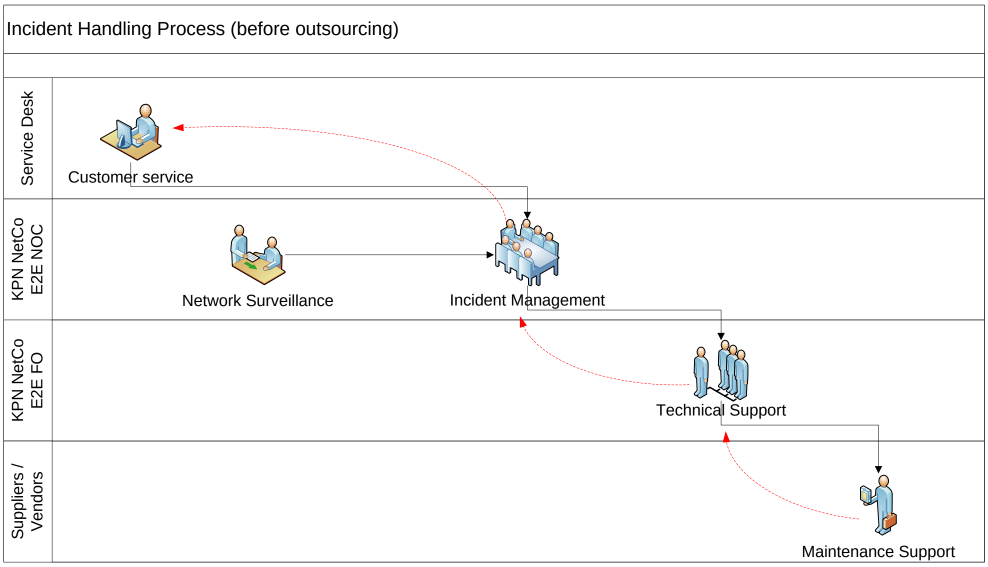
Service level management
Service level management manages the operational SLAs between KPN NetCo and contracted suppliers.

Contract management
Contract management at KPN NetCo E2E FO D&S assures the performance of contracted suppliers in control, according to the agreed operational SLAs.

A.2.4.2 Incident management

The incident management is one important operational process at KPN NetCo E2E FO. Incidents are reported in forms of incident tickets, and come from either a customer call at service desk regarding certain perceived service impact, or a network alarm sent by the network surveillance team at NOC. Under current settings of the incident handling process (Figure A.11), as indicated by the black arrows, the incident tickets are sent to the incident management team at KPN NetCo E2E NOC for initial assessment, and will be further dispatched to the responsible technical teams at 2nd line technical teams from KPN NetCo E2E FO. The incident will be fixed by the 2nd line technical teams, or 3rd line maintenance support from suppliers if necessary. If a ticket is sent to a wrong technical team, it will be sent back to NOC incident management for re-dispatch. In order to avoid the so called 'ping pang' tickets [2], the dispatching quality is of importance to the KPN NetCo E2E NOC incident management and the overall performance of incident handling process. Decisions made during the incident handling process and the fixing results are communicated among the invovled departments/-parties. These communication feedbacks are indicated by the red arrows in Figure A.11.

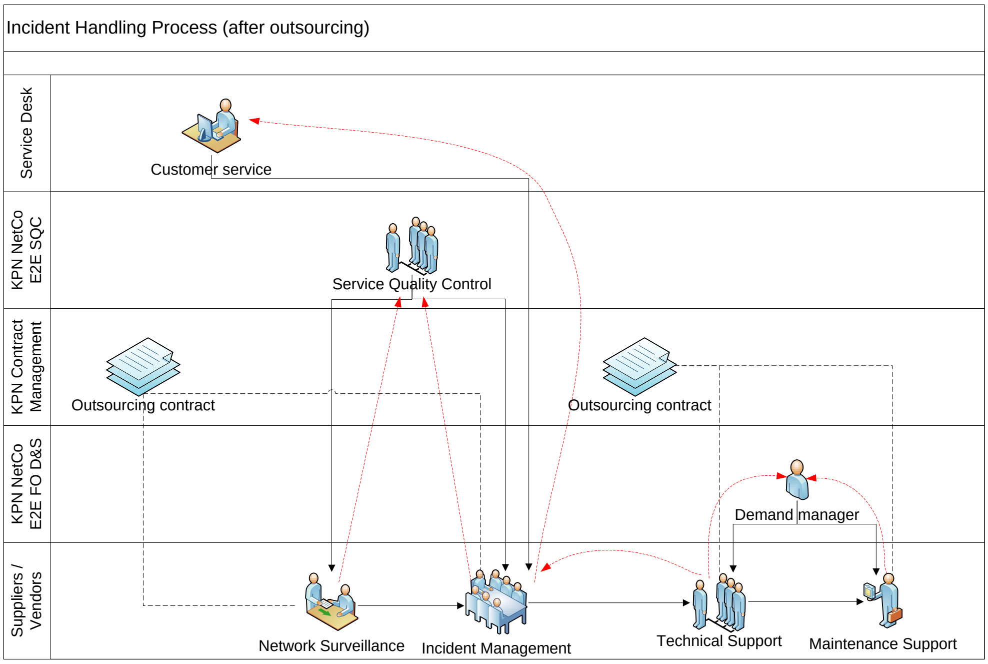
Figure A.11: Incident Management(before outsourcing)



The changes brought by the outsourcing have big impact on the incident handling process (Figure A.12). Firstly a big change will take place at KPN NetCo E2E NOC, who currently has the overall responsibility for network monitoring and incident tickets dispatching. After the outsourcing, the current NOC will be renamed as Service Quality Control (SQC) and takes responsibility only for service monitoring and major events in network, such as severe incidents. As the main monitoring center and technical helpdesk will be outsourced to a remote GNOC, the KPN NetCo E2E SQC will function as the interface between GNOC and KPN NetCo. When there is a severe incident that reaches certain level, it will be reported to KPN NetCo E2E SQC who will initiate a calamity procedure for incident fixing. In addition, the technical teams from KPN NetCo E2E FO who take care of both TI and IT services in fixed-line will be outsourced completely to different suppliers. While the suppliers will take the full responsibility and operations for incident fixing, a demand manager from the KPN NetCo E2E FO D&S holds the steering power over all involved operations in the

[2]A 'ping pang' ticket is the ticket being rejected and returned by a technical team and need to be resend to another one

Figure A.12: Incident Management(after outsourcing)



incident management. The suppliers who are responsible for the technical support and maintaince support need to regularly deliver performance reports to the demand manager. New outsourcing contracts between these suppliers and KPN NectCo will be managed at KPN contract management.

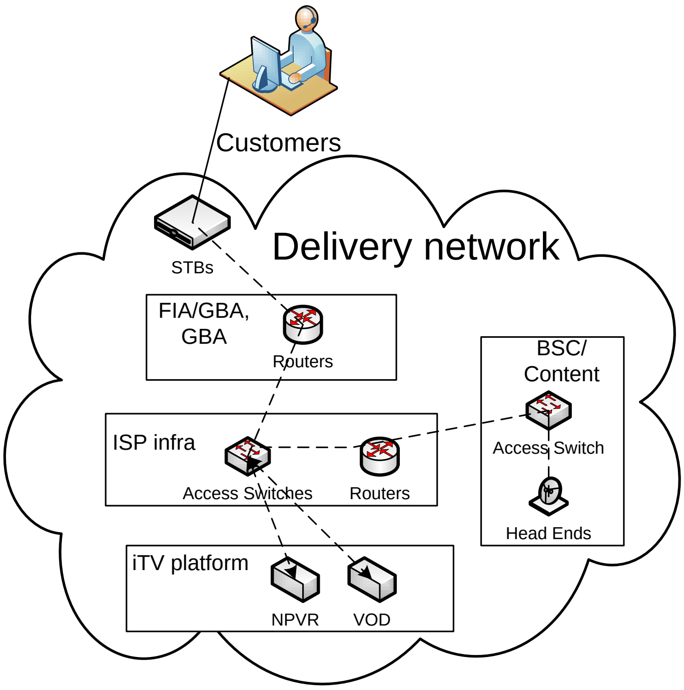
A.2.5 iTV Service

A.2.5.1 KPN iTV service

iTV is one of KPN's innovative service solutions that adds data services to traditional television technology. It provides customers with high level of interactivity with television, so that customers can order, rent, record or replay their preferred or missed programs, and also watch them online via laptops, tablets and smart phones.

Behind the big success, there runs one of the most complex networks for delivering the iTV service. In general the delivery network (Figure A.13) includes the content broadcast service center (BSC/Content), the iTV platform, the internet service provider infrastructure (ISP infra), internet networks (FIA/GIA, WBA), and all the set-top boxes (STBs) installed at customers' homes. In addition to the delivery network, the KPN broadcast service has a national wide 'Media Exchange Network' (MExNet) which is built on KPN glass and serves as the media gateway to transmit video/audio content from sender to KPN business clients and external clients. The content from video/audio distributors is distributed through MExNet and received at the head ends in the BSC/Content. All the functional components of iTV service, such as the vedio on demand (VOD) and the network personal vedio recorder (NPVR), are managed in the iTV platform. The iTV signals are transmitted to the STBs at customers through the IP routing and broadband networks.

Figure A.13: The Conceptual Delivery Network of iTV



The delivery of video/audio content in iTV service is based on multicast technology. For a group of receivers who have common interests, the datagrams are sent to them in the same single transmission. There are one-to-many or many-to-many real time communications between the original video/audio content and receivers over the IP infrastructure network. Using multicast technology increases the efficiency of network infrastructure by sending the required video/audio source packet only once. The network switches and routers replicate the packets to multiple receivers over the network links, which is also done only once for single request.

As a typical telecom network, the access network (the ISP infra and internet network) does not only serve TV broadcasting, but also carry out voice and internet transmission. This implies that multiple innovation and operations departments have access to the same physical network, and any change made by innovation or maintenance in the network may have potential influence on the end-to-end performance of iTV service.

A.2.5.2 iTV service management

The purpose of service management is to provide highly innovative and reliable service to customers. The department responsible for the iTV service management is the

TV&Media (Figure A.14) department from the NetCo FO. Within TV&Media, the development and maintenance of iTV service is carried out by the iTV innovation, the iTV operation and the iTV problem management respectively. The iTV innovation is responsible for the development of iTV service by adding new functionality or improving existing features to iTV service products. The iTV operation makes sure the quality of the iTV service signal at a stable level throughout the delivery network. The iTV problem management tackles any type of problems related with iTV services, including both technical and non-technical issues.

The iTV service is managed collaboratively by the iTV innovation, the iTV operation, the iTV problem management and the NOC (Figure A.15). As iTV is sharing the same access network with other KPN's services, there is also monitoring on iTV's performance ran at the NOC monitoring center. Referring retrospectively to the network events introduced in the fixed-line service (section 6.2.2, Figure 6.4), the management teams of iTV are dealing with the same types of events in the iTV delivery network. The iTV operation is responsible for fixing all the incidents of the iTV service reported by customers or network alarms sent from monitoring systems. The problem management team takes care of all kinds of problems found in the iTV service. The changes implemented in the iTV service are brought by all these three teams. The innovation team develops and implements new services or functionalities to the iTV product. The operation team initiates necessary maintenance changes to operate and maintain the iTV service. The problem management team initiates changes with purpose solving specific problems.

The available personnel capacity for performing the above mentioned operations count on the available personnel and the level of expertise they have. Each team within the iTV management has its own team members who have the same basic knowledge of the iTV service and the delivery network. Nonetheless, regarding the aspects of the iTV service each team is responsible for, different expertise is required to the team members respectively.

Figure A.14: Department Setting of iTV

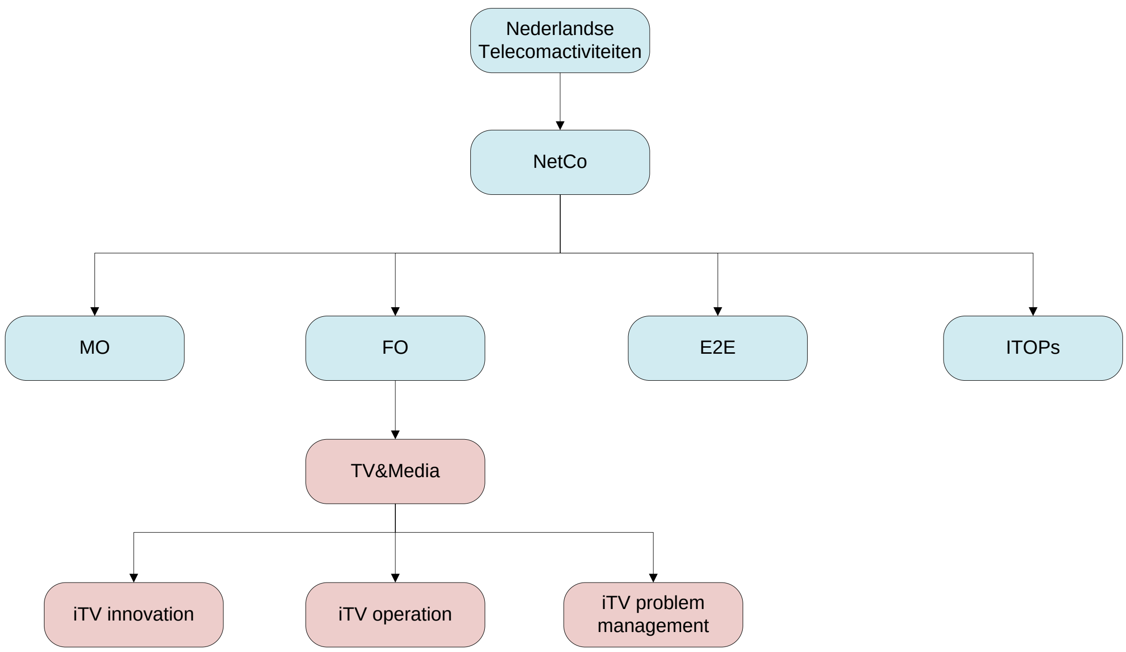
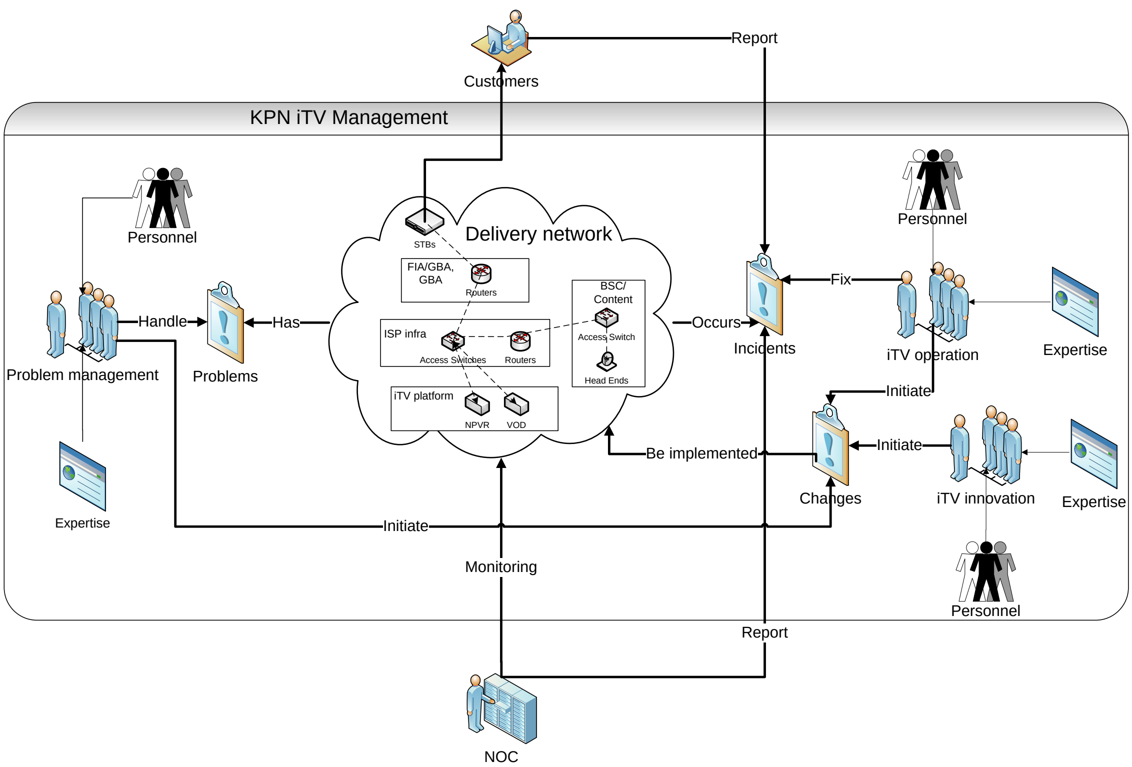


Figure A.15: Structure of KPN iTV Service Management



A.2.5.3 Emergency communication mechanism Be-Alert

KPN has an emergency communication mechanism, Be-Alert, for fixing serious incidents, which aims to form up the calamity team in a best-of-breed manner with respect to the communication with outside, technical expertise, customer relations etc. It takes a customer-centric point of view, since the objective is to remove the customer impact as soon as possible.

The general process of Be-Alert includes five phases, namely run-up, start-up, standardize, completion and aftercare.

- In the initial phase 'run-up', the signaling of service disturbance is received and the global impact needs to be determined. The focus in 'run-up' phase is the speed of classifying the disturbance and deciding a proper calamity process.
- Speed is very important in the 'start-up' phase as well. During this phase, the calamity organization is formed and broad communication with clients, media, government and internal KPN units is commenced. The severity of incident control is related with the degree of the disruption of continuous KPN service, the higher customer impact, the heavier the control.
- Technical solution is implemented during the 'standardize' phase, in which the service recovery should start. During this phase, the communication with clients, media, government and internal KPN units is maintained. The service restoration progress is monitored.
- In the 'completion' phase, the service disturbance is back into control within KPN domain, which does not mean that the customer service is fully restored. The problem is evaluated. It is important to control and communicate about all the relevant issues to the discovery of incident root causes. The calamity organization has less pressure till this phase, but not dismisses yet.
- The disrupted service is fully restored in the 'aftercare' phase. The focus of this phase is to improve the client relationship, the network infrastructure, the calamity procedure, as well as the competence and expertise of users of this calamity procedure.

Incidents are usually reported via customer calling or network monitoring alarming. Given the scale of customer impact, the incidents are classified and colored into four levels, namely (from the most severe customer impact to least customer impact) code red, code orange, code yellow, code blue and code green. Depending on the code an incident receives, the fixing time for corresponding incidents is specified and agreed in SLAs.

A.2.5.4 Incident fixing process

Similar to the incident handling process in the fixed-line service (Appendix A.2.4.2), customers are the one who directly perceive the impaired services. Their reaction (e.g. calling) to the service provider is one of the major indicators for measuring the incident impact [194]. NOC provides monitoring on the status of entire network. In addition, the iTV operations also have system level monitoring on the iTV product. These monitoring systems send alarms to the operations teams when there is any disrupted service activity sensed.

Once an incident is reported, the operations teams are informed and start to restore the disrupted service. According to the operation manager, the incident fixing process includes steps of analyzing the affected service samples, identifying the possible causes, estimating and checking the impact at customer base, proposing and applying proper solutions, meanwhile maintaining the communication with other involved parties and customers.

Regarding the incident situation, the operation teams firstly check the changes implemented shortly before the incident's occurrence for possible diagnostics. Numerous KPN departments may be consulted for root cause investigation. Suppliers as the main application developers are also very often involved in the root cause investigation and further consultations about structural solutions.

A ticketing system is used for recording the communication made by the involved parties during incident fixing. All the communications, including the incident root cause checking and experiments, the decisions made during the fixing process, as well as formal message/conclusion about the service impact, are chronologically documented in the incident tickets. An incident ticket start with the incident registration and end with the service restoration. The closure of an incident ticket implies that the service impact is taken away at customer level, but does not mean the root cause of the incident is structurally removed.

A.3 Case One Additional Material

A.3.1 List of Interviews

Table A.1: List of Interviews / Meetings

Subjects	Interviewees	Organization [3]	Interview dates
Innovation programs	Inge Diepenhorst	KPN ITNL PA&M	8 June 2011
	Alex Koper	KPN ITNL ITOSS innovation	21 June 2011

KPN rapid application design methodology	Debbie Wren	Ivar Jacobson International	8 June 2011
KPN Technical Testing & Release Center (TTRC)	Arnold Abels	KPN W&O	16 June 2011
Network Operation Center	Rob van Asperen	KPN W&O NOC	22 June 2011
Business Control	Jacqueline Wannee	KPN ITNL Fiance	28 June 2011
System Maintenance	Peter de Vriend	KPN ITNL ITOSS	5 July 2011
PMO	Nihairis Ignacius	KPN ITNL PMO (Finext)	11 July 2011
Innovation project: Radion & Prime	Frans van Vugt	KPN ITNL ITOSS innovation	19 July 2011
	Frans van Vugt	KPN ITNL ITOSS innovation	28 July 2011
	Frans van Vugt, Harry Stomp	Ordina	6 October 2011
	Jan Pul	Ordina	19 October 2011
	Han van Lelyveld	KPN ITNL ITOSS innovation	27 October 2011
KPN mobile network configuration	Allard van Bazel	KPN W&O operation	26 October 2011
	Alex Slingerland	KPN W&O innovation	2 May 2012
Innovation project: Release progress meeting	Han van Lelyveld et al.	KPN ITNL ITOSS innovation	15 November 2011
Innovation project: Iteration assessment	Han van Lelyveld et al.	KPN ITNL ITOSS innovation	22 November 2011
Business / IT Alignment survey	Lei Wen	KPN ITNL ITOSS innovation (Logica)	10 April 2012
	Alex Koper	KPN ITNL ITOSS innovation	16 April 2012
	Matthijs Klepper	KPN W&O innovation	20 April 2012
	Alex Slingerland	KPN W&O innovation	5 June 2012
Self-organizing network	Nico de Hoog	KPN W&O innovation	2 May 2012

A.3.2 Survey of Business and IT Alignment Maturity

[3] All the departments / organizations mentioned here only indicate the positions the interviewees held at the moment of being consulted.

Table A.2: Summary of Business and IT Alignment Maturity Survey

	KPN W&O TI Innovation		KPN ITNL ITOSS Innovation	
	Innovation manager	TI network designer	Innovation manager	IT consultant
Communication	In general it is good.	1. Business and IT staff could not understand each other's problem thoroughly, but get complemented by their relative field experience.	1. It may take longer time to understand each other at the beginning of a project, and gets better as the work goes on.	1. It is comparably easier to understand TI designer's requirement. Ordina's explanation is a bit too technical and in detailed solution.
		2. There is frequent and easy connection with IT NL innovation, despite the uncertain availability.	2. The connection and communication with TI innovation go through revolutions and developments.	2. It requires extra initiative in the communication with TI Innovation. Ordina is very friendly and willing to communicate, and has frequent communication.
		3. Due to the long communication chain, information loss is between different departments / organizations.		

Value Measurement	1. TI innovation did not perform well in meeting the deadlines required in the release development.	1. TI innovation performed well, but needs improvement in specification completeness and expression. Time is more critical than cost to project value. The long development chain (TI innovation, IT innovation, Ordina, etc.) is not operated well, so that sometime extra round and more time is demanded, which may hit the project value.	1. Stakeholders evaluated the performance of innovation teams.	1. Performance measurement is not in the work scope.
	2. It is hard to measure project's value.	2. There is evaluation done to the product after the testing phase, which may not be communicated with testing results, but simply solved immediately or require an emergency release. There is no formal matrix to assess what went right / wrong.	2. The success of project is measured in terms of the accomplishment and satisfaction of business requirements. But there is limited benefits tracking to measure the project value.	2. Lessons learned are indicated in every iteration assessment.

	3. More need to be done in improving the requirement specification.	3. The unified process is a very largely overhead for Radion. The responsibility has been split to too many people through too many steps, where in each step it offers some opportunity for miscommunication. Suggestion: lighter (flexible) process, smaller team.		3. A release manager from Ordina tries to improve the process at operational level during every assessment.
Management / Governance	1. The projects are undertaken in supporting the business strategy.	1. Most of the projects are done following the business strategy. But within TI designer's work scope, the work is related with capacity, quality, user experience, efficiency, etc., not directly derived from business strategy.	1. Sometimes there is long distance between business strategy and actual project execution, e.g. long lead time, although the projects do support the strategy.	1. IT consultant does not have a project-wide scope.
	2. The business and IT units have good understanding with each other and clear responsibility.	2. TI and IT innovation have different opinions in prioritizing tasks. There is friction of business priority / technical risk assessment between TI and IT.	2. Something is missing in the big picture of specification of authority and priority distribution between business and IT.	2. Not sufficient authority and priority specification from business side, IT consultant has to specify project priority and negotiate with business units.

Scope & Architecture	1. Configuration management can not be done without IT.	1. There is no clear architectural design of all business processes. There is discrepancy between high level architectural description and low level instruction among existing documents. The most lacking part is the interaction between different processes.	1. There is more or less an architectural design.	1. There is no architectural design, no big picture of business process, IT systems and structure. There are information gaps.
	2. IT innovation positions itself correctly and properly in the business.	2. IT might not help the company to grow, but help to lower the cost, to compete and profit better.	2. IT could help business better.	2. IT always helps. There is room for improvement in translating the business requirements and finding the optimal IT solution.
		3. The scope/position of IT is changing all the time. Within IT innovation, IT has proper scope and satisfies business most of the time. From business perspective, IT does not.	3. IT is on the right track, but sometimes its scope is not clear.	
Partnership	1. TI innovation and IT innovation have mutual perception and agreement on the partnership.	1. The responsibility is not clearly distributed and organized.	In general, it is good.	1. Better partnership with Ordina.

	2. TI innovation is failing; IT innovation is doing well.	2. There is no clear specification regarding the roles, contributions and responsibilities at the company/department border.		2. It needs improvement to have better mutual perception and agreement, when there is new project/innovation.
Skills	1. IT people do understand the business drivers and language.	1. Currently TI innovation and IT innovation have poor understanding of each other's field. It would be better if IT people have better knowledge in mobile radio network. People from Ordina have good understanding and long experience with Radion, which would help lower the friction in the long communication chain.	1. IT people focus on their own perspective, which is good for now, but could be much better.	1. Ordina talks a bit too technically, but is very willing to understand the business.
	2. TI innovation have more difficulties in understanding IT and taking IT's point of view.	2. Sometimes TI innovation does not quite understand IT innovation.	2. Business people think they know IT well. Both business and IT have their own way of thinking and working, and they need to work closer and think for their customers.	2. Business staffs have little time and are not always willing to take responsibility to understand the technical concepts, but just want quick solutions.

A.4 Case Two Additional Material

A.4.1 List of Interviews

Table A.3: List of Interviews / Meetings

Subjects	Interviewees	Organization [4]	Interview dates
Netco fixed network & KPIs	Ruud Slijkhuis	NetCo Voice	5 June 2012
KPI supply chain TL9000	Ruud Slijkhuis	NetCo Voice	19 June 2012
KPI supply chain TL9000	Ruud Slijkhuis	NetCo Voice	28 June 2012
Supply chain KPI proposition	Ruud Slijkhuis	NetCo Voice	16 August 2012
Supply chain dynamics - proposition revision	Ruud Slijkhuis	NetCo Voice	23 August 2012
Supply chain dynamics - incidents	Ruud Slijkhuis	NetCo Voice	20 September 2012
Migration of platform technology	Ruud Slijkhuis & Arnold Abels	NetCo Voice	1 October 2012
Supply chain dynamics - incident process	Ruud Slijkhuis & Gerda Plaisier	NetCo E2E Besturing	2 October 2012
Supply chain dynamics - incident tickets	Ruud Slijkhuis	NetCo Voice	16 October 2012
Supply chain dynamics - incidents	Ruud Slijkhuis & Gerda Plaisier	NetCo E2E Besturing	29 October 2012
Fixed-line service lifycycle	Ruud Slijkhuis & Gerda Plaisier	NetCo E2E Besturing	12 November 2012
KPI framework analysis	Ruud Slijkhuis & Gerda Plaisier	NetCo E2E Besturing	17 December 2012
KPI framework model & incident model	Ruud Slijkhuis	NetCo Voice	22 January 2013
KPI analysis updates	Ruud Slijkhuis	NetCo Voice	5 February 2013
KPN service operations & supply chain KPI tree	Ruud Slijkhuis	NetCo Voice	28 February 2013
KPI analysis overview	Ruud Slijkhuis	NetCo Voice	25 March 2013
Incident handling simulation model	Ruud Slijkhuis & Gerda Plaisier	NetCo E2E Besturing	24 April 2013
Supply chain dynamics - simulation demo	Ruud Slijkhuis & Gerda Plaisier	NetCo E2E Besturing	30 May 2013

A.4.2 Operational Structure of Fixed-line Services

KPN NetCo is gradually outsourcing several service operations in fixed-line services to third party suppliers in the coming years. By the completion of the outsourcing, it aims to achieve an operational structure as shown in Figure 6.2. The E2E services, provided by KPN to end-customers, are delivered via KPN fixed-line network, and supported by NetCo E2E FO D&S deparment, Managed Service suppliers, Maintenance & Support suppliers and the Global Network Operations Center (GNOC) [5]. The managed services in the fixed-line network include:

- Access services and Core services for the telecommunications network
- TI services, such as IP-based Multimedia Subsystem (IMS), Voice over IP (VoIP) and Time Division Multiplex (TDM)
- IT interfaces connecting various IT systems including the billing, operation, configuration, alarm and provisioning systems.

The KPN fixed-line network is managed and configured by NetCo E2E FO D&S together with contracted suppliers. GNOC is monitoring the network, and reports the monitoring data and incident messages to NetCo E2E FO D&S. The Managed Service suppliers report KPI/PI and Reporting Items to NetCo E2E FO D&S, and maintain the interface with suppliers for their Maintenance & Support on operational level. The Maintenance & Support suppliers report KPIs regarding their maintenance support contracts with KPN. Both Managed Service suppliers and Maintenance & Support suppliers have contractual relationship with NetCo E2E FO D&S, and have operational level agreement with each other (Figure A.16).

A.4.3 List of Service Operations KPIs

A.4.4 Detailed Causal Structure of Service Operations

[4] All the departments / organizations mentioned here only indicate the positions the interviewees held at the moment of being consulted.

[5] A GNOC is a NOC, which operates multiple networks of different countries in a centralized location.

Figure A.16: Contractual relations between NetCo E2E FO D&S, Managed service suppliers and Maintenance & Support suppliers

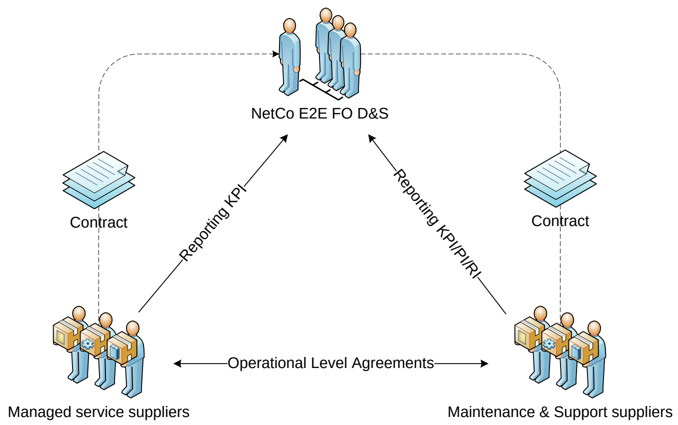


Table A.4: Incident Management KPIs

	KPIs		**Definition**
Incident management	Mean time to restore service	Number of incidents	Number of incident reported
		Incident fixing time	Time spent for restoring an incident
	IRT (Incident Restoration Time) rate within SLA		Rate of incident fixed during solution time as agreed in SLA
	Restoration effort		Work effort (capacity) required for service restoration
	Technical team response time		The time taken between the time an incident reported and the time the correct responsible technical team responds to that incident
	RIR (Repeated Incident Rate)		Number of repeated incidents per period
	Overdue incidents		Number of incidents not restored during agreed solution time
	Restoration FTR (First Time Right) (restoration quality)		Rate of first time right incident restoration

Table A.5: Problem Management KPIs

	KPIs	Definition
Problem management	Number of problems	Number of problems identified
	FRT Problem resolution within SLA	Rate of problems resolved during solution time agreed in SLA
	Number of solved problems	ate of problems resolved during solution time agreed in SLA
	Problem resolution effort	Work effort (capacity) required for problem resolution
	Time until problem identification	The time taken between the time a problem is reported and the time the problem root cause identified
	Number of incidents per known problem	Number of incidents caused by the same identified problem
	Overdue problems	Number of problems not solved during planned solution time
	FTR resolution	Correct execution of problem resolution, first time right

Table A.6: Change Management KPIs

	KPIs	Definition
Change management	Number of changes	Number of authorized major changes
	Number of emergency changes	Number of approved emergency changes
	Number of changes per know problem	Number of change requests for solving identified problem
	Time for change approval	Time taken from change request proposed until change approved
	Change implementation effort	Work effort (capacity) required for change implementation
	Customer complaints from change	Number of customer complaints arise from change
	FTR changes	Correct execution of planned changes, first time right

Table A.7: Release Management KPIs

	KPIs	Definition
Release management	Number of releases	Number of releases rolled out
	Duration of release roll out	Time taken from roll out planning until carrying out
	Release roll out effort	Work effort (capacity) required for release roll out
	Proportion of release distribution	Percentage of un-deployed tasks distributed to new release
	On time T&R (Test&Release) service	% on time readiness of T&R services for projects and changes etc.

Table A.8: Projects KPIs

	KPIs	Definition
Projects	Number of projects	Number of projects with managed service suppliers
	Project capacity	Work effort (capacity) planned for each project
	Number of projects for problem resolution	Number of projects initiated for solving identified problems
	Number of projects for changes in managed services	Number of projects initiated for deploying approved changes in managed services
	Project delays	Number of days out of planned project completion dates
	FTR acceptance	First time right acceptance rate of projects

Table A.9: Configuration Management KPIs

Configuration management	KPIs	Definition
	Number of unauthorized changes	Number of unauthorized changes in the configuration items, e.g. TI&IT infrastructures etc.
	Verification frequency	Frequency of physical verifications of TI&IT infrastructures.
	Configuration coverage	Percentage of configuration items for which data is kept in configuration management system.
	Effort for configuration verification	Work effort (capacity) required for physical verifications

Table A.10: Availability Management KPIs

Availability management	KPIs	Definition
	Level of preventive maintenance	Completeness of preventive maintenance protocol/ mechanism at different levels
	Availability of monitoring	Percentage of services and components under monitoring
	Maintenance effort	Work effort (capacity) required for preventive maintenance
	Number of service interruptions	Number of service interruptions detected at different levels

Table A.11: Performance Management KPIs

Performance management	KPIs		Definition
	Network efficiency	Network load	Network load: e.g. % available trunks on ATM, #concurrent call etc.
		Network redundancy	Measure of redundancy of networks
		Interaction between platforms	The quality of communication between platforms
		% defective service transactions	#defective service transactions / #service transactions

Table A.12: Life Cycle Management KPIs

	KPIs	Definition
Life cycle management	% Defective service transactions	Control of hardware inventory (TI&IT capacity). #defective service transactions / #service transactions

Table A.13: Capacity Management KPIs

	KPIs	Definition
Capacity management	#Customer accounts	Number of registered customer accounts
	#Installed base of client accounts	Number of installed base at customer side
	#Delivered service orders	Number of delivered service orders to customers
	%Delivery on time	Percentage of on time delivery of service order
	FTE forecast	Employee working hours forecast for KPN NetCo E2E FO
	Financial forecast	Budget forecast for KPN NetCo E2E FO

Table A.14: Service Management KPIs

	KPIs	Definition
Service management	#Service issues	Number of issues required in service provisions, which are identified by business unit
	Services covered by internal SLAs	Number of services covered by internal SLAs
	Fulfillment of internal SLAs	Percentage of fulfilled internal SLAs per service per period
	Internal SLAs review	Number of internal SLAs that are regularly reviewed by both business unit and NetCo

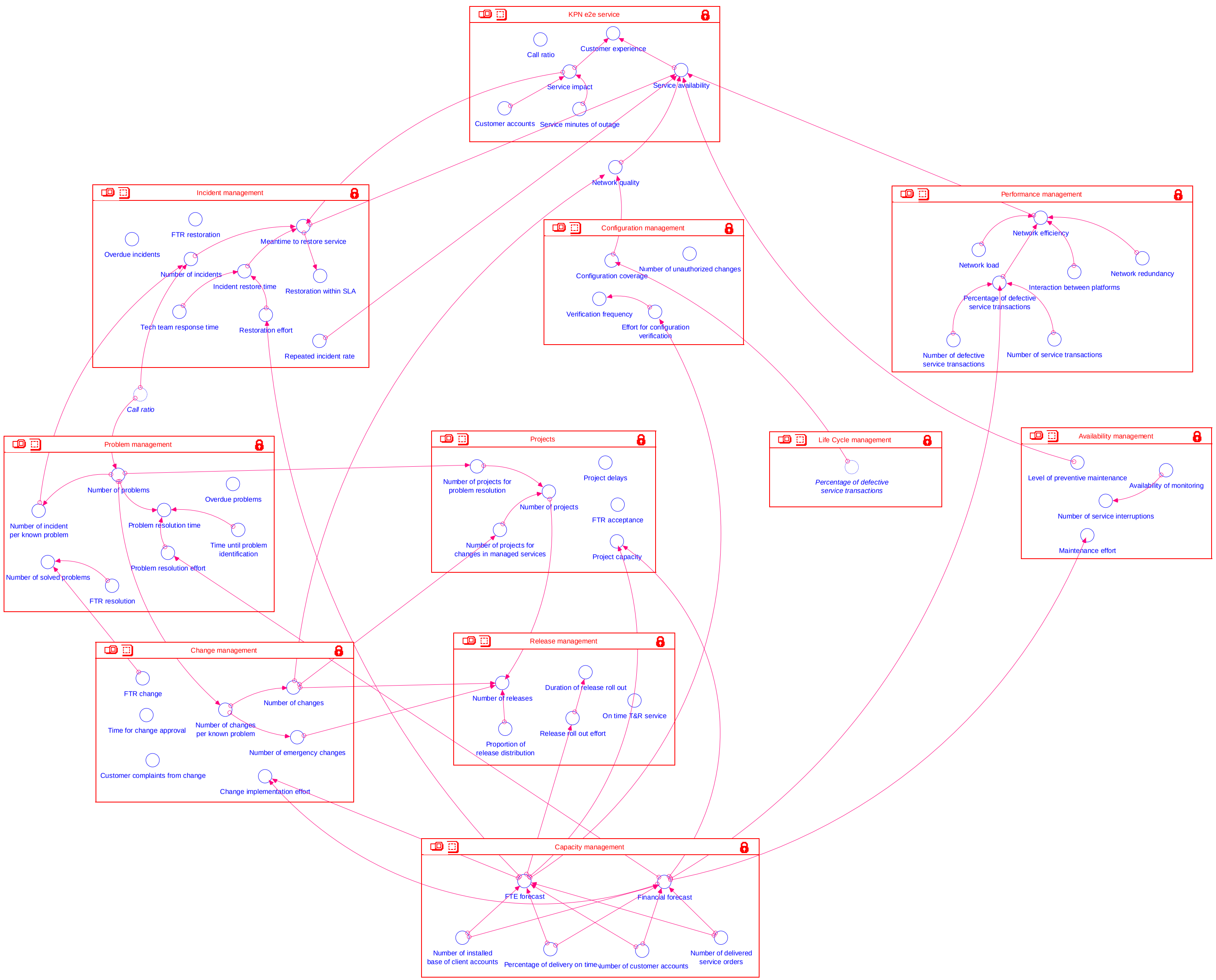
Table A.15: Service Level Management KPIs

	KPIs	Definition
Service level management	Services covered by SLAs	Number of services covered by SLAs
	Monitored SLAs	Number of SLAs under monitoring
	SLAs review	Number of SLAs that are regularly reviewed by both KPN NetCo and suppliers
	Fulfillment of SLAs	Percentage of fulfilled SLAs per service per period

Table A.16: Contract Management KPIs

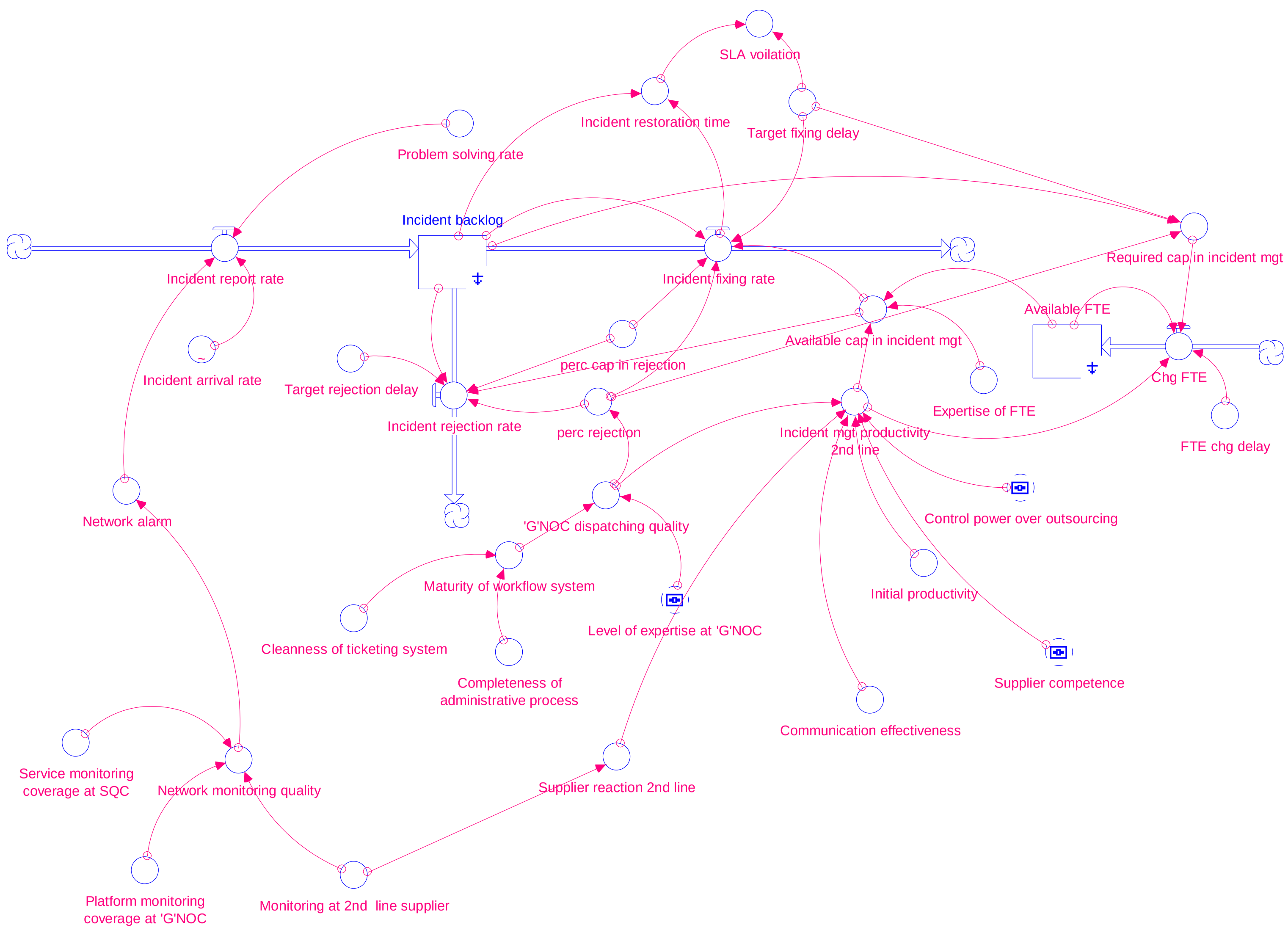
	KPIs		Definition
Contract management	Contract administration	Contract quality control	# regular contract review / improvement # fulfilled supplier contractual obligations # regular supplier competence review
		Complexity of contract creation process	# contractual obligations # contract review/approval steps
		Contract review/termination	# contract going to expire # contract renewed in time # contract terminated Archive management
	Contract creation	SLA fulfillment/violation	The agreed number of SLA violations per time period
		Communication mechanism	On time reporting Supplier response efficiency Level of knowledge sharing
		Information security (Intellectual property protection)	The agreement of knowledge ownership, and control power.

Figure A.17: Detailed Causal Structure of Service Operations



A.4.5 Simulation Modeling

Figure A.18: Simulation Model of the Incident Management



List of Simulation Varables

Table A.17: Simulation Varables

Varables	Definition
Available cap in incident mgt	Number of incidents that can be fixed per week
Control power over outsourcing	The extent that SP (D&S, SQC) in control of the incident management after outsourcing especially in Be-Alert process, on a scale of 0-1
GNOC dispatching quality	Level of first time right ticket dispatching from NOC, on a scale of 0-1
Incident backlog	Total number of reported incidents that wait for dispatching.
Incident fixing rate	Number of incidents that being fixed per week
Incident mgt productivity 2nd line	Number of incident that can be fixed by 2nd line supplier per week per FTE
Incident report rate	Number of incidents that being reported per week
Level of expertise at GNOC	Knowledge level at GNOC, on a scale of 0-1
Monitoring at 2nd line supplier	The monitoring coverage of operational issues changes, on a scale of 0-1
SLA violation	The comparison between the actual incident fixing time and the agreed SLA, unit: week
Supplier competence	Level of supplier expertise, on a scale of 0-1

Case Three Additional Material

A.4.6 List of Interviews

Table A.18: List of Interviews / Meetings

Subjects	Interviewees	Organization	Interview dates
iTV incidents	Ben Perk	NetCo FO TV&media	22 December 2011
	Ben Hearkens	NetCo FO TV&media	22 December 2011

	Rene van Kralingen	NetCo FO TV&media	22 December 2011
iTV incidents	Michel van Egmond	NetCo FO TV&media	23 December 2011
	Anton Khoe	NetCo FO TV&media	23 December 2011
	Paulus de Vries	NetCo FO TV&media	23 December 2011
iTV incidents	Rob van Asperen	NetCo FO TV&media	12 January 2012
	Hennie Eggert	NetCo FO TV&media	12 January 2012
	Roelter Horst	NetCo FO TV&media	12 January 2012
	Nol de Groot	NetCo FO TV&media	12 January 2012
iTV architecture	Daphne Jaspars	NetCo FO TV&Media	6 December 2012
Workshop iTV supply chain dynamics	Peggy Corstens, Peter Claerhoudt, Theo Wakkermans, Anton Khoe, Remko de Boer, Rene van Kralingen, Daphne Jaspars, Anne Cnossen, Arjan Spiering	NetCo FO TV&Media	12 December 2012
iTV operations	Jacques Conijn, Theo Nelemans	NetCo FO TV&Media	20 December 2012
iTV incidents	Anton Khoe, Rutger Vastenburg	NetCo FO TV&Media	15 February 2013
Workshop iTV supply chain dynamics	Peggy Corstens, Peter Claerhoudt, Theo Wakkermans, Anton Khoe, Remko de Boer, Rene van Kralingen, Daphne Jaspars, Anne Cnossen, Arjan Spiering	NetCo FO TV&Media	20 February 2013
iTV incidents	Anton Khoe, Rutger Vastenburg	NetCo FO TV&Media	1 March 2013
iTV incidents	Anton Khoe, Rutger Vastenburg	NetCo FO TV&Media	12 April 2013

iTV incident analysis	Daphne Jaspars, Theo Wakkermans	NetCo FO TV&Media	29 May 2013

A.4.7 List of Workshop Participants

Table A.19: List of Workshop Participants

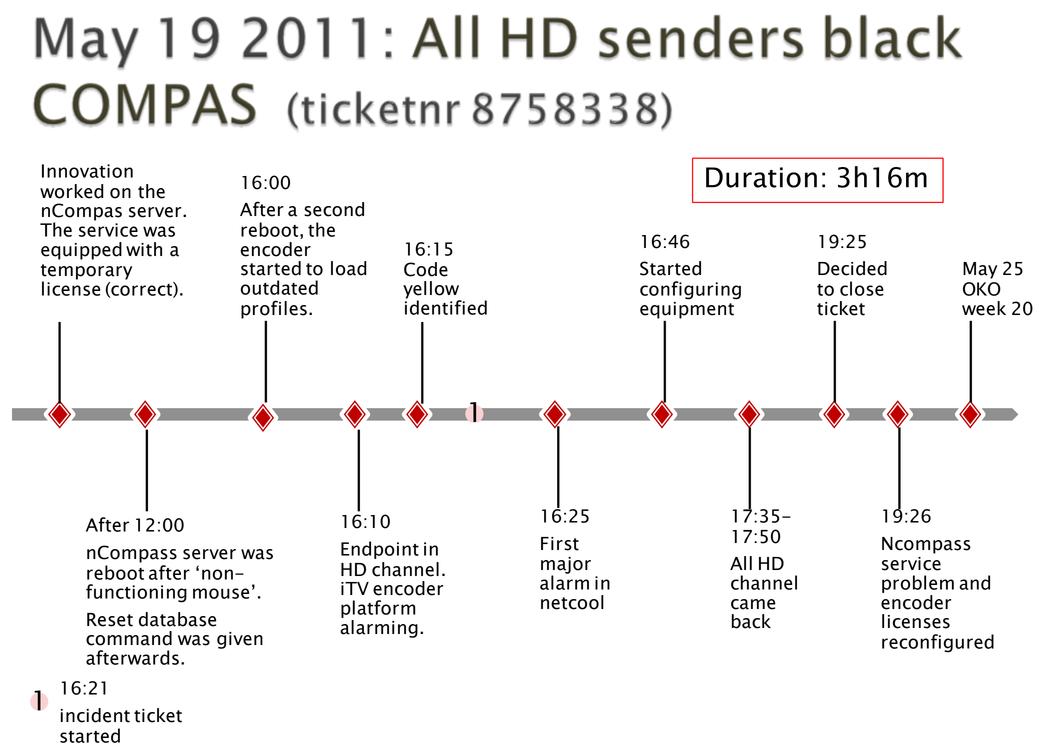
Participant	**Role**	**Responsibility**
Peggy Corstens	Manager TV&M	Overall responsible for the iTV service deliverd by NetCo to its internal customer (RSD) and Wholesale customers
Peter Claerhoudt	Manager Innovation TV&M	Responsible for all innovative activities needed to make iTV a better and more complete product
Theo Wakkermans	Manager Operations TV&M	Responsible for maintenance of the iTV product (both contribution/distribution of content and the Middleware)
Anton Khoe	Manager Beheer IPTV & Streaming	Responsible for maintenance of the middleware in the iTV chain
Remko de Boer	Manager Innovation IPTV	Responsible for the project management of all innovations to be built and delivered by Innovation
Rene van Kralingen	Portfolio manager iTV Innovation	Responsible ofr dealing with supplier Accenture a lot, and translating forecasts into building requests
Daphne Jaspars	Teamlead Service- and Chainmanagement and Servicemanager iTV	Responsible for managing the Service level iTV with internal customer (RSD) and making sure the chain works properly and effectively
Anne Cnossen	Operation upfront manager	
Arjan Spiering	iTV quality manager	

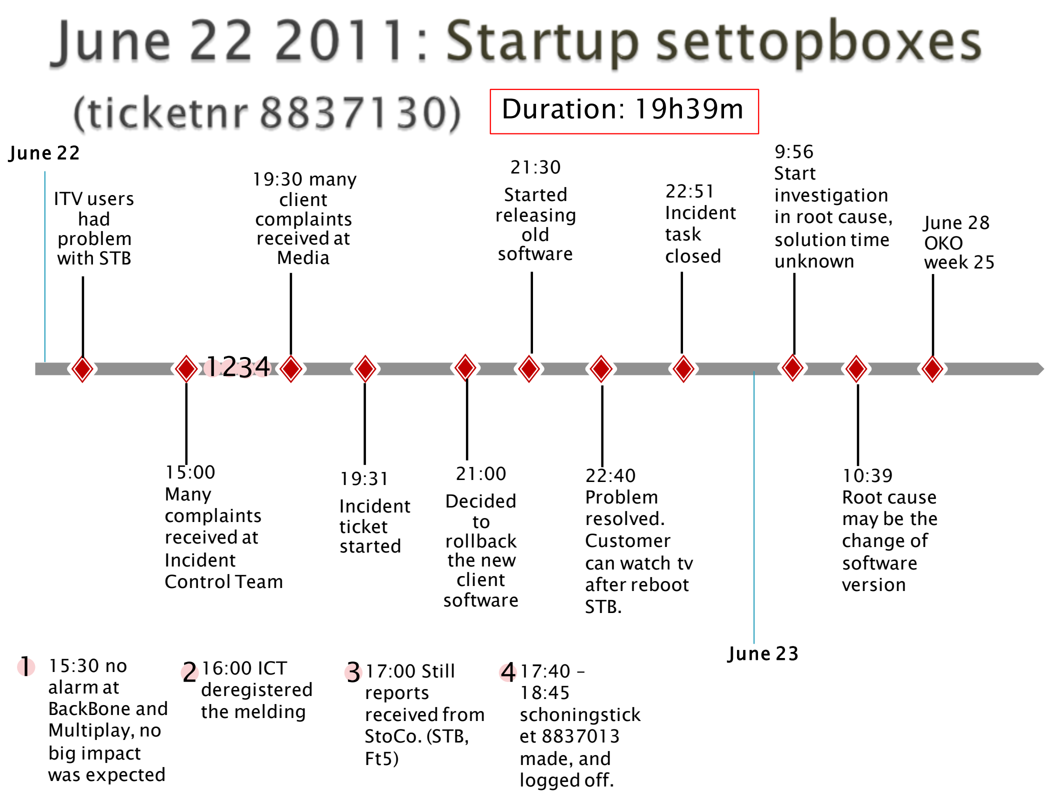
A.4.8 Incident Overview

Table A.20: Incidents Overview

Date	Description	Root cause	Changes	Maintenance	Human error
May 19 2011	All HD channels failure nCOMPAS	Reset database			X
Jun. 22 2011	Startup STBâ€™s	STB's software set up	X		
Jul. 23 2011	ITV Redback router Utrecht	DHCP server problem			X
Mar. 15 2012	Defect using menus by STB software bug	STB's software bug	X		
May 2 2012	Problem by longer maintenance	Maintenance upgrade ran out of service window		X	
Jul. 4 2012	Problem HBO on Demand	Unauthorized nor tested changes from supplier	X		
Sep. 12 2012	Streaming platform disrupted	Driver software bug	X		
Oct. 24 2012	Crashed STB's	STB's Firmware bug	X		
Oct. 26 2012	Inactive customer accounts	Wrong list of customers deleted			X
Nov. 3 2012	Glitches & freezes iTV	A bug in Oracle database	X		

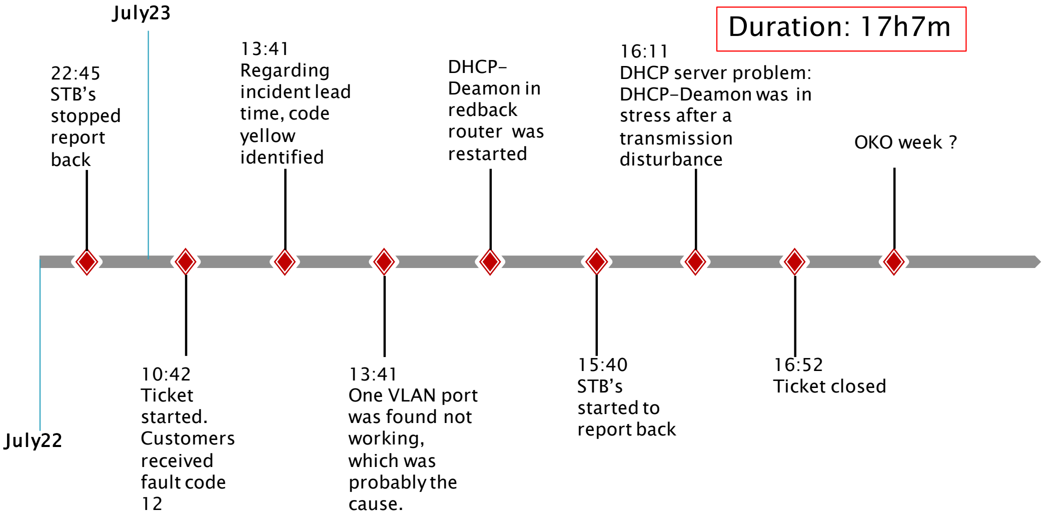
Incident Timelines





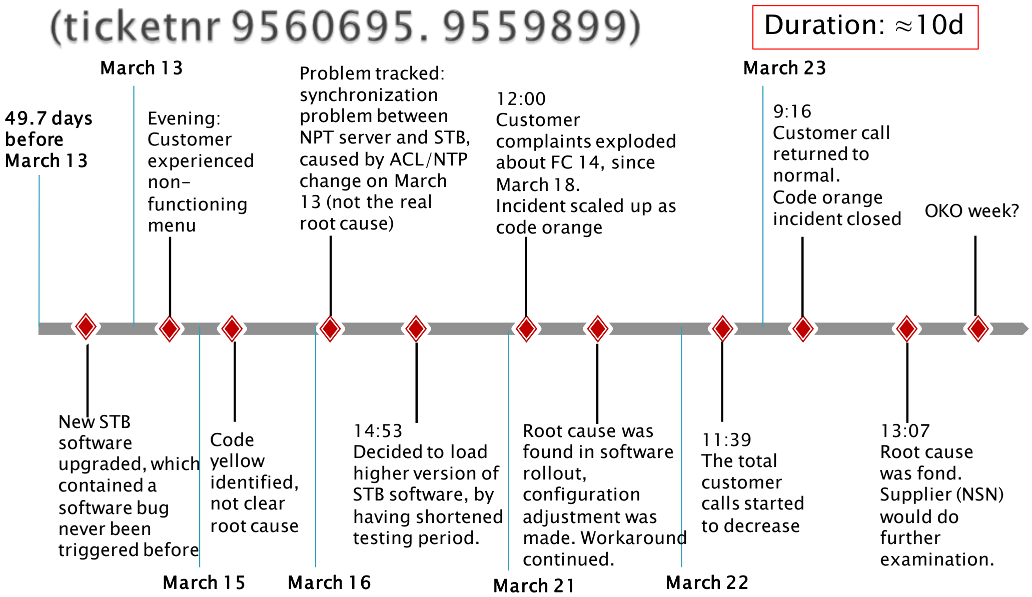
July 23 2011: ITV licenses Utrecht

(ticketnr 8916915, 8916890)

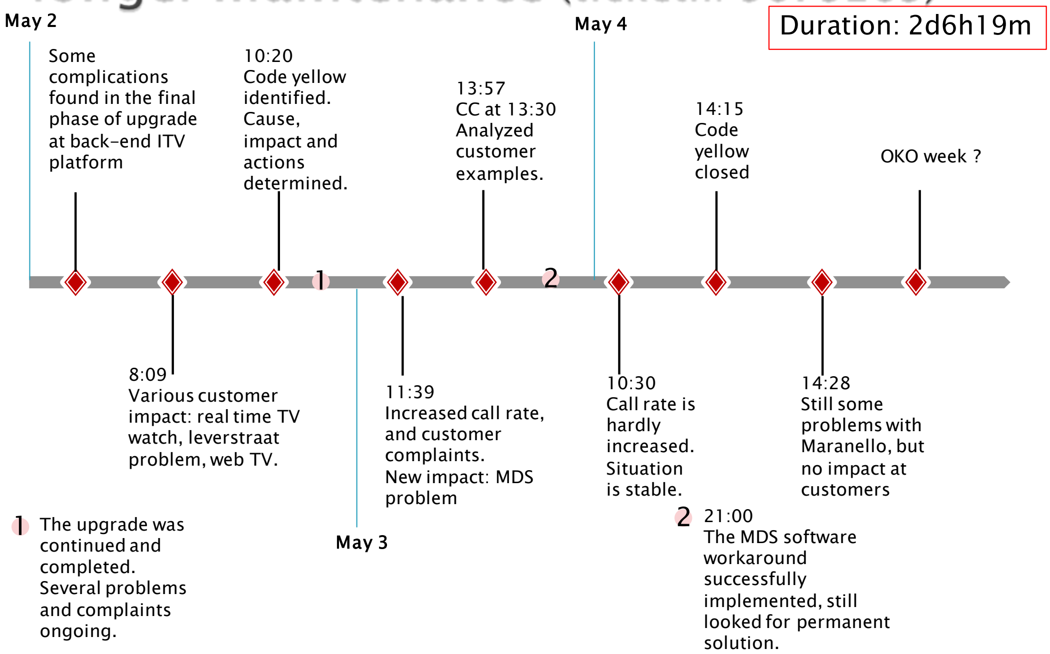


March 15 2012: STB software bug

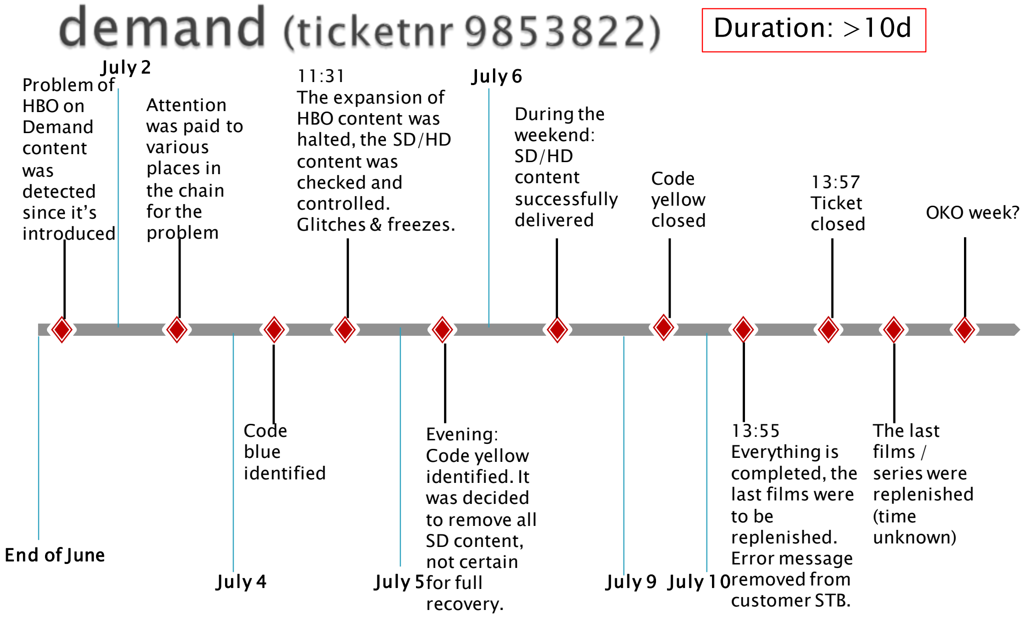
(ticketnr 9560695. 9559899)



May 2 2012: problem caused by longer maintenance (ticketnr 9679283)

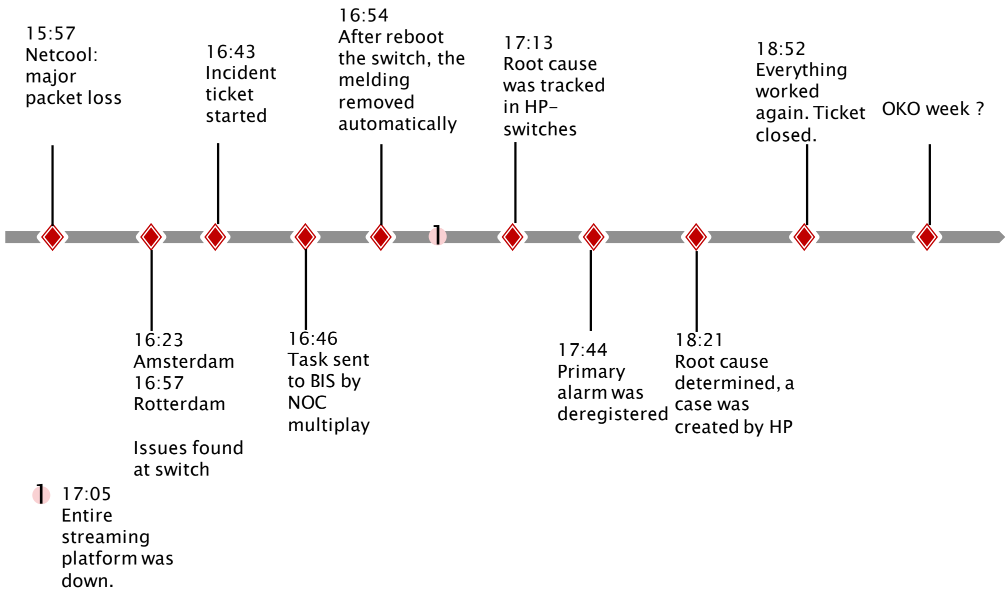


July 4 2012: problem HBO on demand (ticketnr 9853822)

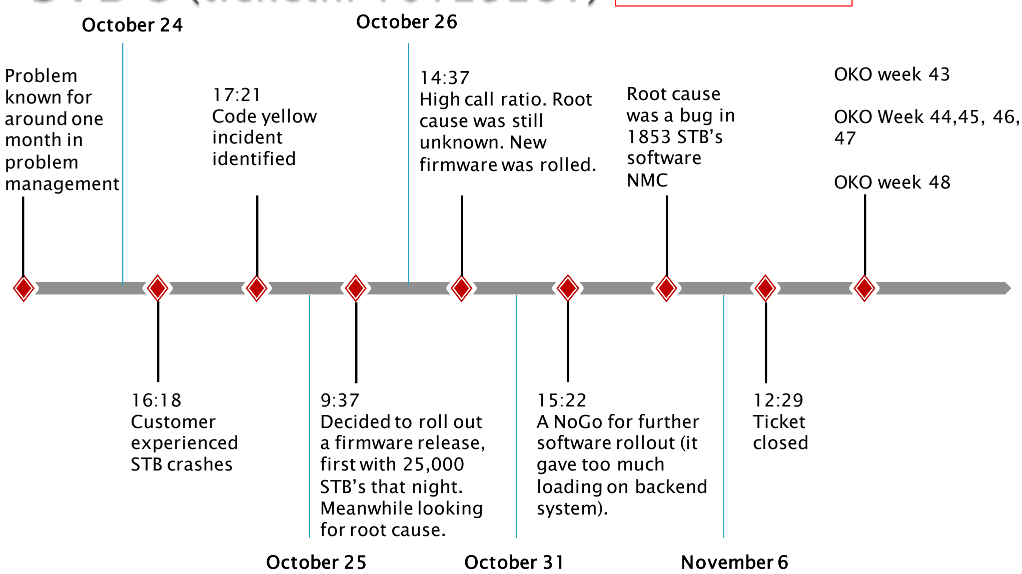


The ticket doesn't contain communication between July 5-9. Timeline is filled with content from evaluation.

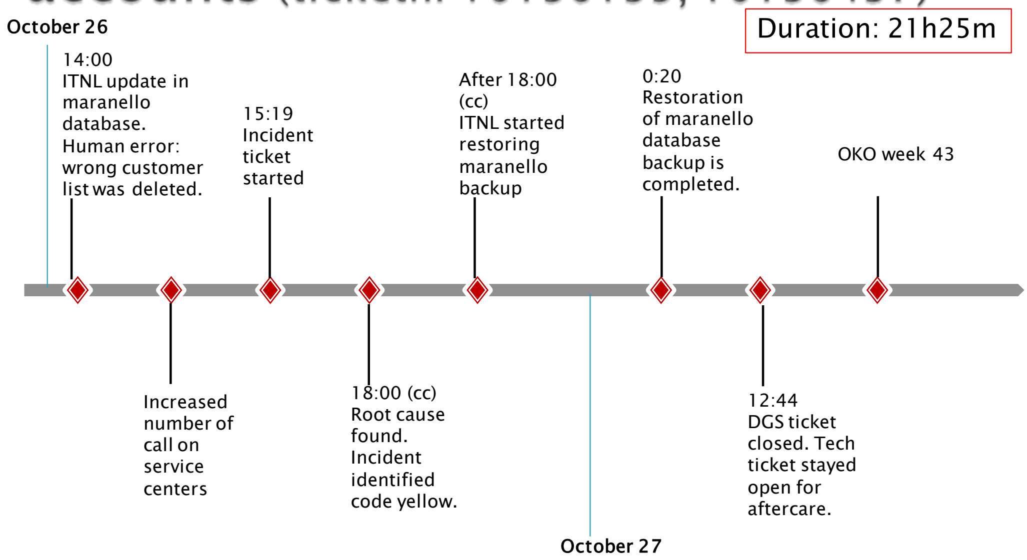
Sep. 12 2012: streaming platform disrupted (ticketnr 10015769, 10015708, 10015729) Duration: 2h55m



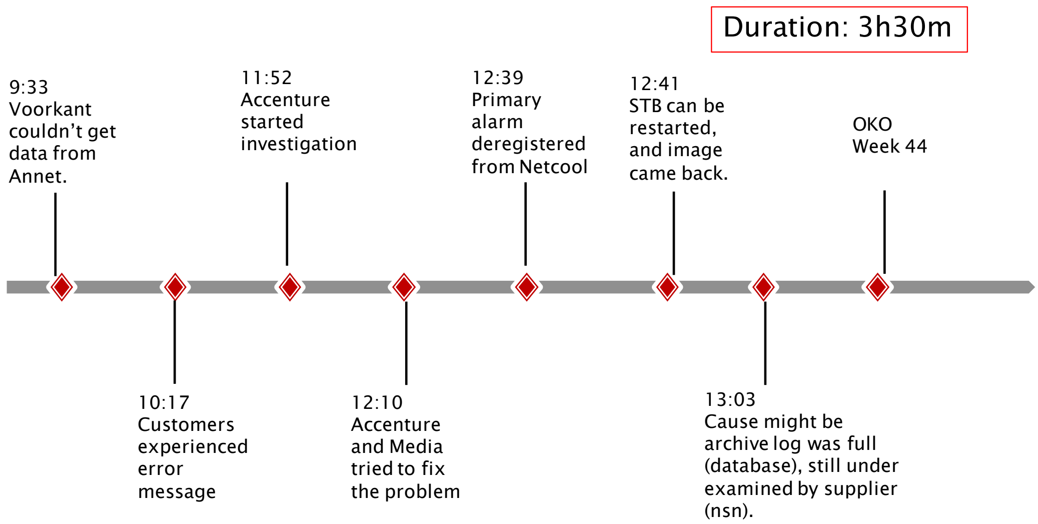
October 24 2012: Vastlopende STB's (ticketnr 10129281) Duration: ≈12d



October 26 2012: inactive customer accounts (ticketnr 10136139, 10136437)



November 3 2012: Glitches & freezes iTV(ticketnr 10158298, 10158138)



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